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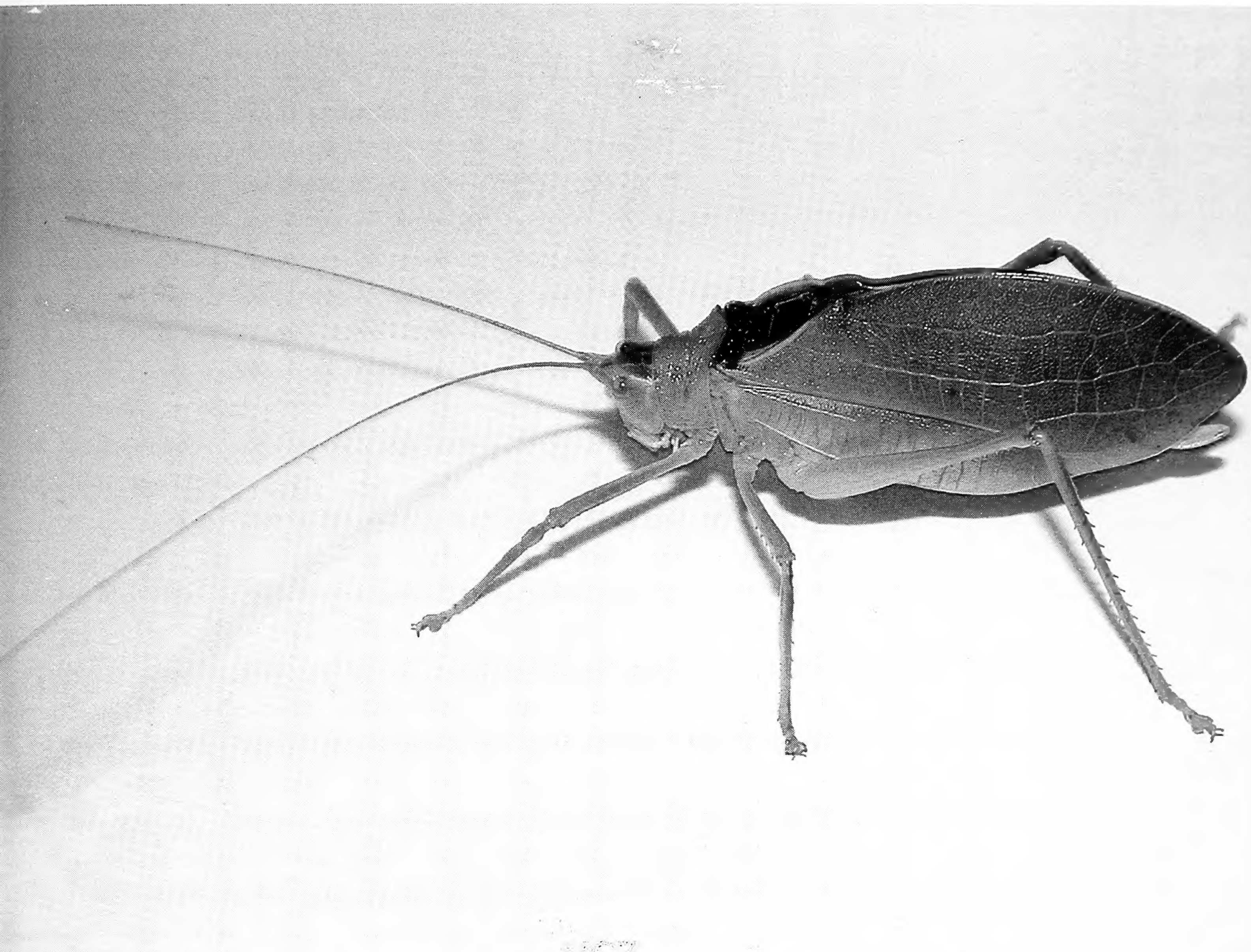

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The Canadian Field-Naturalist

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COVER: A male Northern True Katydid, *Pterophylla camellifolia* Ottawa, from location 3 Figure 1 in Darbyshire pages 124-126. This is the same individual as in Figure 2, page 125. Photographed by Stephen J. Darbyshire.

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THE OTTAWA FIELD-NATURALISTS' CLUB

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Origins and History of The Ottawa Field-Naturalists' Club

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The Ottawa Field-Naturalists' Club (OFNC) represents an unbroken chain of organized, non-governmental natural history investigation and education dating back to the early days of the city of Ottawa itself. The Club originated in 1863 with the formation of the Ottawa Natural History Society which became the Natural History branch of the Ottawa Literary and Scientific Society in 1870, from which the OFNC formally separated in March 1879. Since that time, it has grown into Canada's oldest and largest regional natural history organization and has produced a diverse and internationally recognized publication program. Since 1880 *The Canadian Field-Naturalist* and its predecessors have constituted the scientific core of the OFNC's publication program, with *Trail & Landscape* being an important Ottawa Valley publication since the late 1960s. The importance of both publications to the growth and health of the organization is reflected in the major surges in Club membership experienced when each of these publications was established. The focus of membership activities has changed over the history of the OFNC, with enlightened natural resource management, then original scientific research and local exploration directing energies in the early decades. By the early years of the 20th century the publications program become the *raison d'etre* of the Club, almost to the exclusion of local field activities. A renewed interest in field discovery and the growth of conservation awareness in the 1960s, however, rekindled local activities and re-established the balance which has sustained the organization throughout its history. Natural environment education has remained a critical theme within OFNC programs and activities. Over and above inspiring the professional careers and private interests of thousands of individuals for more than a century, the OFNC has had an important and lasting impact on the conservation of natural environment features and landscapes in Canada and North America.

Key Words: Ottawa Field-Naturalists' Club; Ottawa Natural History Society; The Canadian Field-Naturalist; Trail & Landscape.

Canada was a mere 12 years old in 1879 when 34 members of the Ottawa Literary and Scientific Society (OLSS) gathered together on an early spring evening to discuss a growing problem within Ottawa's fledgling naturalist community. Most were full of Victorian enthusiasm for discovery and intellectual advancement and were convinced of the limitless potential of their new country. These young men – and they were all men, mostly in their 20s or 30s – were frustrated by what they saw as an ineffective, moribund OLSS Natural History Branch which did not serve their needs. These impatient "young Turks" wanted to actually *do* things, to get out into the countryside of the Ottawa Valley to explore and discover its natural wonders. And with true Victorian missionary zeal, they wanted to share these revelations amongst themselves and with the larger Canadian – even international – community. All of this in the name of personal intellectual development as well as the chance to advance the scientific and applied benefits of such knowledge. That was heady, revolutionary stuff in the staid, conservative Ottawa of March 1879 when how close one was to Rideau Hall – the literal and figurative operational base of the Governor General and his politically and socially powerful entourage – dictated more about one's status and options than personal wealth or political position (Gwyn 1984).

The events which unfolded that cool spring evening in the OLSS rooms perched above the muddy streets of Ottawa launched careers, changed government policy, protected tens of thousands of hectares of Canadian natural landscape, produced internationally recognized and significant scientific publications, made huge contributions to our understanding and appreciation of North American natural sciences, and enriched thousands upon thousands of lives. Oh yes … and initiated what has become the largest and oldest regional naturalist organization in Canada's history, The Ottawa Field-Naturalists' Club (OFNC).

The Pioneers (1840s-1863)

Although the formal beginning of The Ottawa Field-Naturalists' Club in 1879 was 125 years ago, naturalists' organizations in the Capital actually pre-date Canada itself (Brault 1946; Dore 1968; Taylor 1986). Prior to Confederation, Ottawa (and Bytown before it) was

a rude little lumber town characterized more by sawdust, beer and brawls than by intellectual achievement. The only adult education or research institution present in those early days was the Mechanics Institute, a charitable organization initiated in 1847 as something akin to a continuing education facility and library for working men. There were no such things as "night school" or public libraries, let alone publicly accessible research organizations. An informal group known as the Silurian Society interested in geological (and mining?) issues was also reported to be active in the 1850s. "Active" may be a misnomer, since they left little reference of their doings, other than to suggest that their meetings were held "in the City of Ottawa" (Anonymous 1854).

The only natural environment research being undertaken in the Ottawa Valley before the 1860s was by three highly active individuals. Edward Van Cortlandt (1805-1875) was the most socially prominent of these. He was one of the first doctors in Bytown, arriving in 1832 to attend to the military personnel stationed on Barracks Hill (now Parliament Hill). He developed an extensive private museum of curiosities and artifacts in the 1840s, liberally mixing archaeological specimens found at aboriginal sites along the Ottawa River with natural items dug up, collected, and/or shot in the vicinity of the town. He was, by all accounts, a remarkably energetic man who used his high social standing to influence local business leaders in natural resource-oriented concerns (Moffatt 1986).

Another dynamo was Elkanah Billings (1820-1876) (Figure 1), second son of one of Ottawa's first pioneer families. Billings was passionately interested in natural history in general and geology/paleontology in particular. At various times he was a newspaper publisher (*The Bytown Citizen*, forerunner of *The Ottawa Citizen*), a lawyer and finally, Canada's first professional paleontologist. Indeed, this latter science was his true calling and he came to be known as "the father of Canadian paleontology" (Whiteaves 1876; Clarke 1971). He presumably was involved in the aforementioned Silurian Society, but no direct evidence of that was found. *The Bytown Citizen* was full of natural history items during Billings's tenure (1852-1856), mostly representing accounts of his own observations or text reprinted from European or American publications. These publication activities led directly to his production in Ottawa of Ontario's first natural science journal, *The Canadian Naturalist and Geologist*, in February 1856 (Figure 2). Delightful and insightful articles in that first volume such as "On the species of woodpeckers observed in the vicinity of Ottawa" (Billings 1856) were based on his extensive travels in the Ottawa Valley. They demonstrated both excellent powers of observation and a keen appreciation of the importance of documenting the appearance and constitution of original landscape conditions. His move to Montreal later that year to join Sir William Logan at the Canadian Geological Survey, however, permanently ended his Ottawa connection (Zaslow 1975).

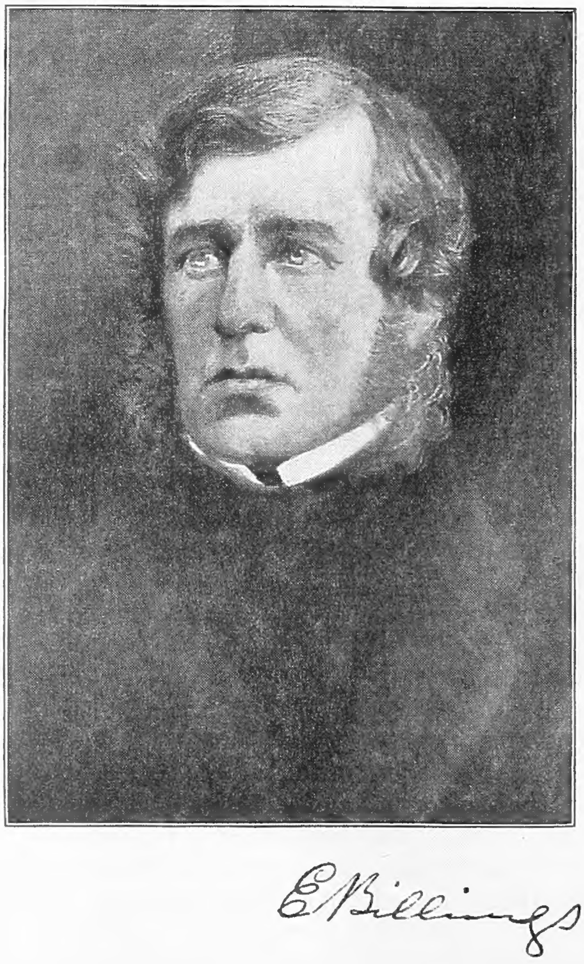


FIGURE 1. Elkanah Billings. Billings was born in 1820, became one of the earliest naturalists in Ottawa, and published the first journal on natural history in Ontario in 1856 (see Figure 2). He moved to Montreal later that year to become the first palaeontologist of the Geological Survey of Canada, and the initial curator of its museum. (reproduction of the OFNC-commissioned portrait, from *The Ottawa Naturalist*, February 1901).

Elkanah Billings' older brother, Braddish Billings Jr. (1819-1871), completes the trio of Ottawa's pioneer resident naturalists. Braddish was a keen botanist and used his position as chief clerk on the Prescott & Ottawa Railway to gain access to a wide variety of habitats across eastern Ontario. Although he published nothing during this time and relatively little even later, in 1868 he did produce the first list of vascular plants for the city of Ottawa. It was a superb effort for its day, chronicling over 400 species that he found within close proximity to the City in 1866 (Dore 1968). Billings was seen as a distinguished figure in natural history investigations in the Ottawa Valley in the 1860s; like his younger brother Elkanah, Braddish was widely consulted by natural science researchers elsewhere in Canada (Dore 1968).

The days of exclusively private investigation of the Ottawa Valley natural environment ended in the early

FIGURE 2. *The Canadian Naturalist and Geologist,* first published in 1856 at the office of *The Ottawa Citizen* by Elkanah Billings, and later continued in Montreal.

1860s with the transfer of the seat of government of the colony of Canada to Ottawa, heralded by the start of construction of the new Parliament Buildings in 1860 (Eggleston 1961). This represented a mega-project with huge economic benefits to local businesses. Similarly, the 1863 transfer of some 300 bright, educated, and relatively financially secure members of the civil service from the old capital represented both economic and social opportunities for the city and the Ottawa Valley. Confederation-era city business and social leaders quickly embraced the idea of broadening and deepening the intellectual resources of the community. In furtherance of this, they encouraged the development of various clubs and societies to enhance the prestige and intellectual capacity befitting the new capital (Brault 1946; Gwyn 1984).

It is useful to consider how really rough and ready Ottawa and the larger world were in 1863. The Arctic was still largely unknown to Europeans and North Americans alike but was being charted with great speed by the continuing search for the ill-fated Third Franklin Expedition. The United States Civil War and the accompanying ferocious slavery debate raged uncomfortably close to the south, as did intense arguments in the Old World regarding the newly published (1859) "heresies" of Charles Darwin's *On the origin of species*. Closer to home, Ottawa was a bustling, rapidly growing city of approximately 15 000 people which boasted but a single operating sewer line along Wellington Street in front of the new Parliament Buildings. The first railway train had puffed into town fewer than ten years earlier and a municipal drinking-water system was still 12 years off (Brault 1946; Eggleston 1961). Ottawa was very much straddling the line between pioneer lumber town and developing political centre.

The Ottawa Natural History Society (1863-1869)

It is against this backdrop that a veritable "Who's-who" of the new business and professional elite of Confederation-era Ottawa (notably including both the aforementioned Edward Van Cortlandt and Braddish Billings Jr.) assembled on 3 October 1863 to form the Ottawa Natural History Society (ONHS). These gentlemen – and the ONHS constitution made it clear that membership was open *only* to gentlemen – were very economically oriented. The original minute books maintained in the OFNC collection at Library and Archives Canada (LAC) records that they were " … desireous to develope [sic] the Natural History of the Ottawa and general resources of the surrounding country" (LAC OFNC Collection, 3 October 1863). Exploring and researching the natural sciences of the Ottawa Valley were all well and good but these gentlemen – at least initially – wanted to see a profit result from it.

An important aspect of the growth of such endeavours was the potential participation of the relatively large body of newly arrived civil servants (Brault 1946). Activity within quasi-professional associations (it's called "networking" today) was a very important unofficial avenue for professional advancement within the small professional community of public servants in the Capital at this time (Gwyn 1984). The ONHS offered such an outlet and avenue for civil servants interested in natural resources and natural environment issues. A definite pecking order mirroring that of their professional relationships was soon evident amongst founding ONHS members who were also senior civil servants. When powerful Finance Department Deputy Minister John Langton (1808-1894) was ONHS President in the late 1860s, for example, his ambitious subordinate, Interior Department Deputy Minister Edmund Meredith (1817-1898), was conspicuously involved in the organization, but was careful not to hold higher office nor to publicly disagree with Langton (Gwyn 1984). The social/political significance of the organization, over and above the fact that 77 men paid the $1.00 membership fee for 1863/1864, can also be meas-

ured by the prominent involvement of individuals such as Sir James A. Grant (1831-1920), the Governor General's personal physician (Travill 1988) (LAC OFNC Collection, 3 October 1863).

The ONHS members chose widely appreciated and politically-neutral Braddish Billings Jr. as their first president, although he was not very active in subsequent Society affairs (LAC OFNC Collection, 3 October 1863 – 28 October 1864). The Council (Board of Directors) soon established a schedule for regular meetings and made arrangements for the development of "The Cabinet", a series of cases displaying natural history specimens which were to be held in the rooms they rented at the Mechanics Institute building on Sparks Street. Van Cortlandt was elected museum curator for the Society and remained in that position throughout the life of the organization.

Although precise records are sketchy, records at Library and Archives Canada indicate that the Society met regularly for lectures and field trips. The last Saturday of each month was fixed for the latter (LAC OFNC Collection, 28 April 1865), during which members actively searched for natural history specimens for The Cabinet. Indeed, this seemed to be a major focus of the organization (Dore 1968). In October 1869, only months before the organization's amalgamation with the Mechanics Institute, Braddish Billings offered his herbarium to the ONHS for $60 (LAC OFNC Collection, 1 October 1869). Although no supporting motion for such a purchase is noted, Billings's collection did end up there (it may have been deposited after his death), and was examined in the OLSS museum in the 1880s (Fletcher 1888). Unfortunately, the OLSS herbarium, including the Billings's specimens, disappeared sometime in the early 20th century (Dore 1968).

The ONHS seems to have been most active between 1865 and 1867 and to have achieved considerable standing in the community. In 1866 a group met with federal Minister Thomas Darcy McGee to discuss a possible ONHS – Mechanics Institute exhibit in the 1867 Paris Exhibition (LAC OFNC Collection, 26 April 1866). Their paths had crossed before, in Quebec City in 1862-1863, McGee had lectured to the Quebec Literary and Historical Society along with both E. A. Meredith and John Langton. And while the subject of his speech was not recorded, the Governor General apparently spoke to the Society shortly thereafter (LAC OFNC Collection, 25 May 1866). Within a month of Confederation an ONHS delegation led by President N. B. Webster lobbied Prime Minister John A. Macdonald to have the Geological Survey Museum moved to Ottawa from Montreal (LAC OFNC Collection, 26 July 1867) – possibly the first such initiative in the lengthy campaign to effect such a transfer (Zaslow 1975). Similarly, early concerns for habitat protection and landscape conservation were discussed amongst the Society's influential membership through presentations like Vice-President Thomas Austin's lecture "The Ul-

TABLE 1. Elected positions of Ottawa Natural History Society (1863 to 1869) [from LAC OFNC Collection 3 October 1863 – 30 December 1869]

	1863/1864	1864/1865	1865/1866	1866/1867	1867/1868	1868/1869	September-December 1869
President	B. Billings Jr.	N.B. Webster	N.B. Webster	N.B. Webster	J. Langton	J. Langton	E. A. Meredith
1st Vice-President	N.B. Webster	George Hay	T. Austin* J. Langton*	J. A. Phillipps	J. A. Phillipps	E. A. Meredith	J. A. Grant
2nd Vice-President	J. Thorburn	J. Thorburn	J. A. Phillipps	J. Langton	E. A. Meredith	J. A. Grant	J. Thorburn
Secretary	T. Austin* J. Thorburn*	T. Austin	T. Daniel* J. Thorburn* W. White*	W. White	W. White	W. White	W. White
Treasurer	J. Featherstone* F.D. Laughlin*	J. A. Grant* J. Ogilvie	J. Ogilvie	J. Ogilvie	J. Ogilvie	J. Ogilvie	J. Ogilvie
Corresponding Secretary	n/a	n/a	n/a	D. Dodd	A. Harvey	A. Harvey	W. D. LeSueur
Curator	E. Van Cortlandt	E. Van Cortlandt	E. Van Cortlandt	E. Van Cortlandt	E. Van Cortlandt	E. Van Cortlandt	E. Van Cortlandt

* held position for a portion of the year

terior Effects of Clearing off the Forests and Draining the Country" (LAC OFNC Collection, 26 April 1866).

While The Cabinet may not have survived, the Society left a more lasting (albeit, modest) record through its publications program. It commenced in 1867 with a pamphlet on the possible economic uses of Milkweed (*Asclepias syriaca*) by Alexander Kirkwood (1823-1901) who, with the timely promotional assistance of ONHS member and OFNC founder Henry B. Small Sr. (1832-1919), would later be the driving force behind the establishment of Ontario's Algonquin Provincial Park (Killan 1993). The ONHS published 250 copies of Kirkwood's lecture (Kirkwood 1867). Approval for the production of 250 copies of a lecture by Van Cortlandt entitled "Native Compounds and Metallurgy of Iron" was given by the Council the previous year but there is no evidence that a publication actually resulted (LAC OFNC Collection, 28 December 1866). After a year of discussion and buoyed by the success of the Kirkwood pamphlet, however, an ONHS *Transactions* series was initiated. It was short lived, producing only three numbers.[1]

Faced with rising financial pressures (including the costs of renting rooms) and the opportunity to formally combine resources (including a provincial operating grant), the ONHS decided in the spring of 1869 to merge with the Mechanics Institute (LAC OFNC Collection, 16 April 1869). The minutes books describe surprisingly little of the ensuing discussion, but the Society did merge with the Institute to form the Ottawa Literary and Scientific Society (OLSS) on 24 December 1869 (LAC OFNC Collection, 30 December 1869). The ONHS Cabinet became the basis for the OLSS museum, whose collections disappeared with the dissolution of the Society in 1906-1907. Unpublished biological data were apparently also maintained in the Museum, however, as indicated by later reference (containing several errors in fact) being made to "lists published by the Ottawa Natural History Society of 1859–63" (Small 1883).

Although active for only a decade, the ONHS was critical in the awakening of interest in the organized and documented investigation of natural sciences in the Ottawa Valley. It bridged the gap from hit-and-miss personal interest to organized and semi-professional investigation. It also initiated the concern for and participation in larger issues of national science policy, research priorities, and natural environment conservation which continue within the Ottawa naturalist community to the present day.

The Ottawa Literary and Scientific Society and OFNC formation (1870-1879)

The combination of the ONHS and the Mechanics Institute appears to have been seamless, with the members of the ONHS effectively becoming the Natural History Branch of the newly created OLSS. Little documentation was found, however, concerning the resulting organization in general and the activities of its Natural History Branch in particular. Nonetheless, the OLSS was a socially and culturally significant organization in Victorian Ottawa by the end of the 1870s, supporting a regular lecture series, a public reading room and a lending library of 1100 volumes (LAC OFNC Collection, OLSS brochure). Despite the larger city population, better local research resources and the existence of a potential sponsoring organization, however, there are few indications of more than individual efforts in natural science investigations in the Ottawa Valley. At the least, the momentum of the 1860s seems to have been stymied within the larger, predominantly culturally-oriented OLSS. The stage was set for a final transformation of the ineffective OLSS Natural History Branch into a new and more productive structure … an independent naturalist group.

If the organization that morphed into the OFNC actually began in October 1863, the final stage of its transformation was achieved with the cordial separation of the Natural History Branch from the main body of the OLSS in March 1879. It appears to have been a classic example of a group of activists becoming dissatisfied with the pace and effectiveness of a well-established group and deciding that the only way to achieve more contemporary goals was to strike out on their own. The fact that most of the prime movers and shakers in the new organization were established members of the old OLSS and remained members for years thereafter, indicates that they retained faith with the original organization as a valuable forum for intellectual development and social debate. Nonetheless, they wanted to see more activity and greater opportunities being provided for natural environment investigations (Harrington 1909).

Once again, national and world affairs played an important role in the development of naturalist organizations in the Ottawa Valley. Canada was experiencing the early years of a serious economic downturn that lasted into the early 1890s (Eggleston 1961). At the same time, the promise of this new country and the political, social and economic difficulties of the Old World were encouraging huge numbers of young, relatively well-educated and mobile immigrants to enter Canada; some stayed and some moved on in this time of social and economic upheaval. The decade following the founding of the OFNC, for example, saw the highest number of both Canadian immigrants and emigrants of any time in the 19th century (Lingard 1967).

Young Turks and Rebels (1878-1879)

The group which gathered in March 1879 to consider a new natural history organization in Ottawa reflected its times. This included a mix of Ottawa veterans enthusiastic about the future, as well as young, newly-established civil servants, and British immigrants full of imperial fervour. They seem to have been imbued with Victorian optimism about the importance and strength of ideas, a missionary zeal for discovery and the sharing of knowledge, and a strong desire to con-

tribute to their community (LAC OFNC Collection, 25 March 1879-15 December 1879). Some stayed on to become important participants in the exploration of the Ottawa Valley natural environment while others followed different paths elsewhere in Canada and beyond.

The founding meeting was called by James Fletcher (1852-1908), OLSS museum curator since 1878 and an up-and-coming entomologist and botanist (Figure 4). Fletcher had emigrated from England in 1874, moving to Ottawa in 1875 to work as a clerk in the Bank of British North America and joining the Parliamentary Library staff as an accounting clerk in 1876 (Cody et al., 1986). He was a gregarious, personable, and physically active man who quickly became deeply involved in sporting and social activities. He was, for example, a keen snowshoe racer and a founder and principal player with the Ottawa Football Club, a rugby team which later evolved into the Ottawa Rough Riders Canadian Football League team (Harrington 1909). He was also a pillar of the Anglican Church community in Ottawa and remained so throughout his life. And, while being a young man with shallow Ottawa roots, his social profile, and thus influence, improved dramatically when he married Eleanor Schreiber (daughter of Sir Collingwood Schreiber, Chief Engineer of the Canadian Pacific Railway and later Chief Engineer of the Department of Railway and Canals) in 1879.

Fletcher's enthusiasm, intelligence, and boundless energy quickly became known to the small group of active field naturalists already resident in Ottawa and he was eagerly sought out (Whyte 1909). Chief amongst these field associates and life-long friends were Robert B. Whyte (1851-1918), an Ottawa-born private businessman and passionate horticulturalist (Macoun 1918) (Figure 5). The other was William (Will) H. Harrington (1852-1918), a skilled entomologist and botanist who moved from Nova Scotia in 1870 and spent his entire working career with the federal post office department (Gibson 1918). While Whyte is credited with the *idea* of an Ottawa Field-Naturalists' Club, Fletcher is universally credited with being the fellow who made it happen and saw to it that it became firmly established (Harrington 1909; Whyte 1909).[2]

The dynamic trio of young naturalists were not alone in this, and were joined by an eclectic mixture of OLSS members who also felt the need for an organization focusing exclusively on natural sciences. Many were prominent in the building of Ottawa and/or the federal civil service of the new country (Brault 1946; Gywn 1984). These included former ONHS officer and senior Post Office Department official William White (1830-1911) (Figure 3); lawyer and politician (later, Premier of British Columbia) Joseph Martin (1852-1923); former ONHS officer, teacher, and Geological Survey of Canada (GSC) librarian John Thorburn (1830-1904); author and later Deputy Minister of the Interior Henry Small Sr., and the OLSS president of the day, prominent literary patron and Secretary (Deputy-Minister) of the Post Office Department, William D. LeSueur (1840-1917) (LAC OFNC Collection, 25 March 1879).

As noted earlier, the social and political prominence of members was important to the success of such organizations in Victorian Ottawa (Gywn 1984). This early naturalist community (Table 2) was small and remarkably homogenous, dominated by white, English-speaking, Anglo-Saxon protestants who worked, lived and even were buried in close proximity. Overwhelmingly, the children of most early club leaders were enrolled in the Ottawa Collegiate Institute (MacMillan et al. 1904), and numerous Club officers – including almost two dozen former Presidents – are buried at Beechwood Cemetery. Beechwood, appropriately enough, was also a favoured 19th Century OFNC excursion site (Reddoch 1979c).

Founding Meeting (25 March 1879)

The special meeting of OLSS Natural History Branch members was called to order in the OLSS museum at 112 ½ Sparks Street by James Fletcher (Figure 4) on 25 March 1879.[3] It seems that the politics of Victorian Ottawa immediately intervened, however, as William White (Figure 3) and R. J. Wicksteed moved

TABLE 2. Participants at inaugural meeting of the OFNC, 25 March 1879 (LAC OFNC Collection, 25 March 1879).

W. P. Anderson	L. A. Hamilton	Dr. Ross
E. D. Arnaud	W. H. Harrington	H. B. Small Sr.
Prof. George Baptie	G. Heron	H. B. Small Jr.
W. R. Billings	G. A. D. Jones	P. D. Symms
W. Chesterton	E. V. Johnson	John Thorburn*
L. H. Chrysler	W. D. LeSueur*	H. Watters
R. A. Davy	J. Martin	W. White*
James Fletcher	B. Monk	R. B. Whyte
J. M. Greta	S. McLaughlin*	R. J. Wicksteed*
J. MacD. Gordon	Prof. W.R. Riddell	A. P. Wright
J. A. Guignard	C. J. Ripley	
D. Horsey	P. Robertson	

*member of ONHS (1863-1869)

FIGURE 3. Lieutenant-Colonel William White, May 1901. White was the first president of the Ottawa Field-Naturalists' Club, and also the Ottawa Horticultural Society. Earlier he was president of the Ottawa Athenaeum and Mechanical Institute. Photographer William James Topley, Ottawa, archived at the Library and Archives of Canada, Ottawa: E 81666).

that fellow ONHS veteran John Thorburn chair the meeting. Perhaps to counter this old guard move, newcomers Joseph Martin and Henry B. Small Jr. subsequently moved that Fletcher be made Secretary of the meeting. The social pecking order apparently satisfied, Fletcher then got discussion under way (LAC OFNC Collection, 25 March 1879).

After some debate of whether to stay affiliated with the OLSS or to form a separate group, the actual motion to establish an independent OFNC was moved by Joseph Martin (seconded by R. B. Whyte): "... that it is advisable to form a Field Naturalists Club for the City of Ottawa and do proceed to organize".

It was only after this motion had been passed that Fletcher reported to the gentlemen assembled that a small group (consisting of at least James Fletcher, Will Harrington, R. B. Whyte (Figure 5), Joseph Martin, and Henry Small Jr.) had actually held preliminary consultations on 11 March 1879 to prepare a proposal to the Council of the OLSS – and no doubt, to map out strategies. At that preliminary meeting they had drafted a motion (Fletcher, seconded by H. B. Small Jr.) that in light of "... an Ottawa-Field Naturalists Club having been organized in Ottawa...", this new group " ... would gladly contribute to the Museum of the OL & S Society and thereby revive its present dormant condition". In exchange, they asked that the OFNC be allowed to use the OLSS rooms for meetings. An additional clause asking that the new organization be "under the auspices" of the OLSS was an apparent face-saving offer, since the OFNC had virtually nothing further to do with OLSS programs.[4] The resolution was passed by the OLSS Council, though there likely was little else they could do, being presented with such a *fait accompli*. There may have been a good bit of bluff on the part of Fletcher and his associates, however, since the Club did not in fact exist on 11 March when the motion was drafted!

If this was not-too-subtle political manipulation by the newcomers, the old guard may well have reaped a bit of revenge in the election of OFNC officers which followed immediately thereafter. William White, long-time Ottawa resident, former Mechanics Institute president and ONHS member, was elected President. It is not recorded in the Minute Books if the officer positions were contested that day, as was often the case in the first years of the organization. Likely more important than being an ONHS veteran, White was a senior Post Office Department official and was socially prominent as Lieutenant-Colonel of the Governor General's Foot

FIGURE 4. James Fletcher in June 1908. He called the founding meeting of The Ottawa Field-Naturalists' Club and was the prime architect of its early success. Photographer William James Topley, Ottawa, archived at the Library and Archives of Canada, Ottawa C96620).

Guards (Shutt 1912; Anonymous 1929). His election, however, may very well have also been the wish of the newcomers since White's Rideau Hall connections made the important task of securing the agreement of the Governor General to serve as Club Patron that much easier.

The minutes of the founding meeting (LAC OFNC Collection, 25 March 1879) are very sparse in detail. As Secretary, James Fletcher would have produced a hand-written record of events. The preserved minutes are in the handwriting of R. B. Whyte, however, indicating that Fletcher's record of events was rewritten. The development of this simplified record could perhaps have allowed for the tactful omission of politically delicate matters such as contested positions and/or heated exchanges.

In any event, James Fletcher was elected First Vice-President and the Council and Officer positions were filled by other young rebels (R. B. Whyte, Henry B. Small Jr., W. H. Harrington, and Joseph Martin) or neutral figures (W. R. Riddell and J. A. Guignard) (Appendix 1). Only one Council position was filled by a White associate, William P. Anderson (1852-1927), who also later became Lieutentant-Colonel of the Governor General's Foot Guards (Small 1929). As it turned out, however, Fletcher essentially ran the affairs of the OFNC in 1879 and 1880, with White playing a very low-key role.

Earliest Days (1879 – 1880)

The first Council meeting of the new Club was held under the chairmanship of William White on the afternoon of 3 April 1879 in the Museum of the OLSS (LAC OFNC Collection, 3 April 1879). It was followed almost immediately by another, longer session at the home of William Anderson on 5 April 1879 to prepare details for a formal members' General Meeting the following Tuesday (8 April 1879) and to accept the resignation from the Council and from the Club of J. A. Guignard. No reasons were given for the speedy and rather dramatic resignation of Guignard but despite being James Fletcher's assistant at the Experimental Farm from 1891 onward, he did not ever rejoin the Club. He did, however, function as Acting Editor of *The Ottawa Naturalist* for several months in 1903 (Brunton 1986a).

The Ottawa Field-Naturalists' Club first met publicly on 8 April 1879 under the chairmanship of James Fletcher with about 25 members in attendance in the Museum of the OLSS. Operational rules for the Club were described, a Corresponding Members (Honorary Member) designation was identified, an active excursion program was laid out, and a membership fee (50¢ per annum) was established. The fee was half that established by the ONHS 16 years earlier, presumably in an effort to keep membership in the OFNC more affordable for the general public. And also unlike the ONHS, the OFNC specifically identified membership as being open to both "ladies and gentlemen desiring to join the Club" (LAC OFNC Collection, 8 April 1979).[5]

There were 25 OFNC Council and public meetings held in 1879/1880, the busy first year of the newly independent Club. Most of the public meetings were in the form of somewhat informal soirées in which lectures were followed by opportunities for debate and conversation. Through this year the Council addressed numerous details of the developing organization including the arrangement of Vice-regal patronage, the establishment of an active excursion program, the selection of the first OFNC Corresponding Member (John Macoun [1831-1920]) (Brunton and Gummer 1987), and recognition of the importance of "public education" (the first glimmers of conservation action?). James Fletcher was everywhere in this, conducting excursions, conducting and documenting field research, and handling many logistical details. President White chaired 12 of the meetings that year, only a few more than Fletcher, who oversaw nine because of the president's frequent absence (LAC OFNC Collection, 1879-1880).

The establishment of various scientific working committees (botany, ornithology, geology, etc.) generated a great deal of interest and field activity within the Ottawa District[6], resulting in considerable natural environment information being gathered. Membership grew to almost 100. The influence of Lieutentant-Colonel White and others secured the patronage of the Governor General and made OFNC membership socially desirable. This was aided by the membership within the first year of prominent individuals like the previously-mentioned Governor General's personal physician, Sir James Grant; the founder of the Central Experimental Farm research institution, Sir William Saunders (1836-1914) (Anstey 1988; Cody et al., 1986); and prominent scientist, engineer, and inventor Sir Sandford Fleming (1827-1915) (Regehr 1988).

The lectures delivered at the Soirées were well received, leading to requests for their publication for the benefit of members and other interested parties alike. The March 1880 Council meeting established that a transaction of the OFNC's first year be produced. Five hundred copies of that first *Transactions* were published for a cost of $78.43, likely in June 1880 (Brunton 1986a) (Figure 8). In appreciation of his production of the lithographed plates for the publication at no cost, the Council granted Club membership for the year to J. A. Guignard – the same gentleman who had resigned from the Council as well as from Club membership, only days after the Club had been formed (LAC OFNC Collection, 28 July 1880). This was done again in 1882 for additional *gratis* lithographic services, so it appears that whatever difficulty Guignard had with being on the Council and being a voluntary Club member, he was prepared to receive and work for the publication.

FIGURE 5. Robert B. Whyte, (June 1908), was first secretary-treasurer and later president of the Ottawa Field-Naturalists' Club. Photographer William James Topley, Ottawa, archived at the Library and Archives of Canada, Ottawa: C 105521).

Publication of the *Transactions* was the first step in a renowned publication program that, to date, has produced seven annual *Transactions of The Ottawa Field-Naturalists' Club,* almost 120 volumes of *The Ottawa Naturalist/The Canadian Field-Naturalist* and almost 40 volumes of *Trail & Landscape*. Complete sets of *The Canadian Field-Naturalist* and its predecessors are rare, however, particularly so in private libraries. Likely fewer than a dozen complete sets exist in Canada. The *Transactions* are especially rare publications, several of which became unavailable within a few years of publication. Only 75 copies of *Transactions* 1 were still available by early 1884, for example (LAC OFNC Collection, 12 March 1884), and only "virtually complete sets" were being sold (for $24) by 1909 (LAC OFNC Collection, 23 February 1909).

The Late Victorians (1880s-1890s)

The OFNC was a huge hit at the height of the Victorian era in Ottawa. Aided by improved transportation – most particularly, the expansion of railways up the Ottawa and Gatineau Valleys – and the continued growth of both the federal civil service and the city (exploding to 60 000 by 1899 – Brault 1946), huge strides were being made in the exploration and understanding of the natural biodiversity of the Ottawa Valley. Transfer of the Geological Survey of Canada from Montreal to Ottawa in 1880 (Zaslow 1975) and with it, many of the top natural scientists in Canada, provided a major boost to the OFNC. So too did the 1882 arrival of John Macoun (Macoun 1922). Through their network of professional connections, Macoun and other scientists at "The Museum", as it was known, also provided an important link between OFNC members and national and international floral and faunal authorities. Despite becoming increasingly preoccupied with professional duties after he became Dominion Entomologist and Botanist in 1886 (Cody et al., 1986) and being troubled by serious eyesight problems for a period of time (LAC OFNC Collection, 17 March 1885), James Fletcher remained an inspirational and hands-on leader within the OFNC throughout the 1880s and 1890s.

Club membership had more than doubled to 254 by 1899 (Figure 6). This was due to both local and wider-scale influences. On the local front, OFNC excursions became major social events and major generators of additional interest in the organization (Reddoch 1979c). These were often huge events, with trains being chartered to take upwards of 300 participants on day-long trips. Fortunately, many sites now well within the urban core of the National Capital Region were in close to original condition then and became prime locations for many formal and informal outings. Chief amongst these were Lac Leamy, Fairy Lake, and Wychwood (Aylmer) in Gatineau, and Rockcliffe Park, Beechwood Cemetery and the Billings Bridge (Rideau River) area in Ottawa. Further afield, the huge Mer Bleue peat bog and Casselman to the east, and King Mountain and Chelsea to the north offered "exotic" destinations that were visited repeatedly (Reddoch 1979c).

In striking contrast to the early to mid-19th century days of the ONHS and its predecessors, these efforts were well documented in OFNC publications. The annual *Transactions*, modelled on the *Transactions of the Manchester Field-Naturalists' Society* (Brunton 1986a), were produced through much of the 1880s. Each *Transactions* reproduced Club lectures delivered during the previous year. More importantly, they included annual reports of various committees highlighting the field discoveries of members. The *Transactions* thus provided the first documentation of a variety of comprehensive lists of Ottawa area flora and fauna, such as birds (White and Scott 1882), vascular plants (Fletcher 1880), and fish (Small 1883). Against these, individual members could compare and direct their own field investigations and discoveries. Fletcher's serialized, annotated revision of the 1880 list of vascular flora was produced over many years thereafter, providing a continuing enumeration of new discoveries and potential exploration sites for OFNC members (Boivin and Cody 1955).

After seven annual *Transactions* had been produced, there were increasing calls for a more frequently appearing publication. This was particularly important for the description of new species (LaRocque 1931), the first being a new fossil which had been described in *Transactions* 2 by Sir James Grant (Grant 1881). At the March 1887 Annual Meeting members agreed to initiate a monthly publication series which could move beyond the simple publication of Club lectures and reports. This was over the objections of W. P. Anderson, the current OLSS President, who had complained the previous fall of OFNC "antagonism" towards the old Society (see above); he wanted the *Transactions* to stay as they were (LAC OFNC Collection, 14 March 1887).

The first issue of *The Ottawa Naturalist* was published in April 1887 under the editorship of Will Harrington, who also had headed up the editorial committee which produced the last (1886) volume of the *Transactions* (Brunton 1986a). *The Ottawa Naturalist* was a small (21 × 14 cm), slim (16 page) publication produced on a shoe-string budget (150 copies at $18.50 per issue) (LAC OFNC Collection, 10 March 1887). Even then, such a cost was considered a financial difficulty for the Club (Harrington 1887) but was off-set to some degree by the sale of advertising space on the back cover. These advertisements included notices to such "critical" products and services for the attention and consideration of Ottawa naturalists as G. W. McCullough's Anthracite and Bituminous Coal, C. Ross & Co.'s "Beautiful selection of Dress Silks being offered at 75¢ per yard", and Miss Harmon's Boarding and Day School for Young Ladies.

Not only the advertisements may have met with amusement or disapproval in the eyes of some. In 1888 the always feisty John Macoun expressed the opinion that "too much trash was now published", and that "the majority of papers were of little or no value …"; that the accounts of Excursions were "all but worthless". It is not recorded what Editor Will Harrington might have thought upon hearing this (he undoubtedly was present), but OFNC president R. B. Whyte was not amused by Macoun's intemperance. Whyte stated that he " … wished to record his expression as directly opposite [Macoun's] and thought the publication was of much interest to the members" (LAC OFNC Collection, 9 March 1888).

Regardless of the reservations of people such as William Anderson and John Macoun, *The Ottawa Naturalist* established a new standard for the timely presentation of technically sound, original scientific information which has continued seamlessly to the present day. Its launch, however, was also *far* from the last time controversy and disagreement would characterize discussion and debate about OFNC publications!

Both the growth in local capacity for natural environment research and the evolving vision of the Club's role are indicated by Council's November 1887 rejection of a gift of biological specimens from Corresponding Member and American entomologist Henry Edwards (1830-1891) (Fletcher 1891). The Council (with both John Macoun and James Fletcher present) suggested that the potential donor should offer the plant specimens to the herbarium of the Central Experimental Farm (DAO) which had recently been started by Fletcher and is now the largest collection in Canada (Rothfels 2003); they further suggested that Edwards's insect specimens be offered to the Geological Survey Museum (LAC OFNC Collection, 18 November 1887). There was no discussion of a donation to the OLSS collection, nor of initiating an OFNC museum or cabinet. Neither, it appears, was deemed appropriate in light of the existence of these growing, professionally based research collections.

By the end of the 19th century, the personality of the Club had also evolved considerably. The OFNC was now administratively well established and boasted a program of regular meetings and excursions. It enjoyed a strong reputation for community involvement, produced a steady stream of field-based scientific findings, and even demonstrated a measure of political prominence with Laurier government cabinet ministers and future provincial Lieutenant-Governors as members. The parent organization from which it had split off, on the other hand, was in serious decline and only a few years from dissolution. The young turks who had rescued the OFNC from the moribund OLSS Natural History Branch were middle aged and well established now, a number having become respected senior scientists and policy makers. *The Ottawa Naturalist* remained a monthly publication but had grown in size and enjoyed much improved printing quality. Articles often now were accompanied by illustrations, these sometimes being photographic. *The Ottawa Naturalist* was gaining a wider readership too, with articles addressing subjects considerably further afield than the Ottawa Valley, such as the review of the status of bird species in King's County, Nova Scotia (Tufts 1898; 1899a; 1899b).

But portents of future conflicts and a growing divergence of visions could be sensed. Founder and Past-president R. B. Whyte, for example, complained about the Nova Scotia bird articles. He felt *The Ottawa Naturalist* should not be publishing material so far removed from the Ottawa area. Botanist James M. Macoun (1862-1920) and geologist Henry Ami (1858-1931) disagreed, suggesting that the Club publication fulfilled an important role here. Other new members supported Macoun and Ami and called for a greater number of rigorously scientific, more broadly based articles to be included in the publication (LAC OFNC Collection, 14 March 1899).

In other words, a new group of younger, more vigorous, field-oriented naturalists – including a number

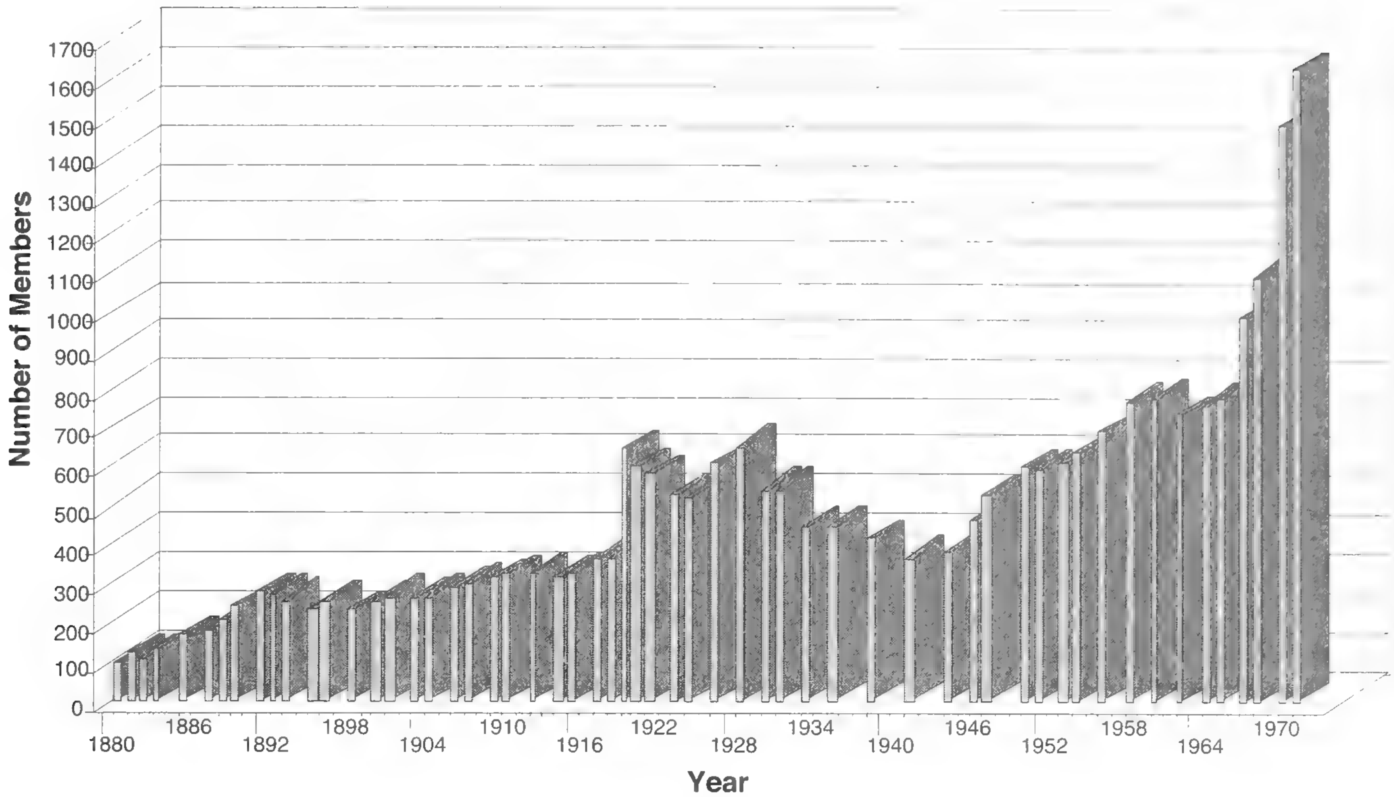
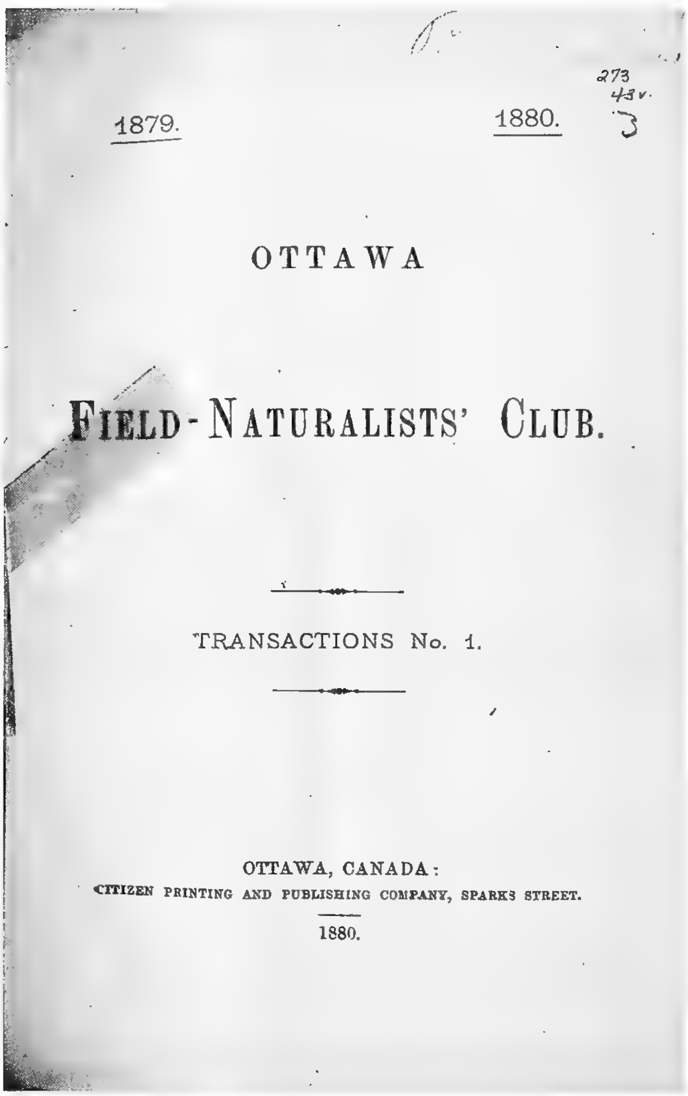


FIGURE 6. Ottawa Field-Naturalists' Club membership trend, 1879/1880 to 1974. Membership lists until 1971 (published in *The Canadian Field-Naturalist* until the early 1950s and/or reported in published Annual Reports) included all addressees to which *The Canadian Field-Naturalist* was sent. After 1971, however, the membership totals exclude non-voting subscribers and thus are no longer directly comparable to earlier numbers. Where gaps on the membership data occurred, such as when no lists or Annual Reports were published in some years in the 1920s, an intermediate estimate was entered.

FIGURE 7. A geological field trip of The Ottawa Field-Naturalists' Club along a railway rock cut north of Chelsea Grove in the Gatineau region of Quebec, north of Ottawa. The area's oldest and youngest deposits are in direct contact here. The trip leader was Dr. Henry Ami. From *Trail & Landscape* 13(3): 94; prepared from a lantern slide original by Dr. Ami, now in the Library and Archives of Canada, Ottawa.



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43 v.
1879. 1880. 3

OTTAWA

FIELD-NATURALISTS' CLUB.

TRANSACTIONS No. 1.

OTTAWA, CANADA:
CITIZEN PRINTING AND PUBLISHING COMPANY, SPARKS STREET.
1880.

FIGURE 8. The initial issue of *The Ottawa Field-Naturalists' Club Transactions,* the initial annual publication series of The Ottawa Field-Naturalists' Club.

of the first wave of trained professional biologists to work in the federal government – were becoming prominent in the organization, changing things, and arguing for a more national perspective. This was not entirely to the liking of at least some of the long-established Club leadership. The situation must have had ironic echos for the elders of the Club like Whyte, Harrington, Small, and Fletcher, for in the days leading up to the founding of the Club *they* were the "young turks" eager for change!

Memorials and the Great War (1900-1915)

Despite the economic trials of much of the late Victorian era, it was a positive period of establishment, growth and achievement for the OFNC. By the turn of the 20th century, it had become one of the largest and most prominent such organizations in Canada. Events of the next decade and a half would sorely test that status, however.

Symbolic of the coming of age of the OFNC and the end of its establishment period was the death of Queen Victoria in 1901. The OFNC pioneers, after all, were either originally emigrants from Great Britain or were locally-born in colonial times. The black-edge, memorial issue of *The Ottawa Naturalist* in February 1901 (Figure 9) expressed in its frontispiece tribute the heart-felt distress at the passing of an era: "In common with all the sorrowing subjects of His Imperial Majesty King Edward the Seventh the members of The Ottawa Field-Naturalists' Club desire to record their deep sense of sorrow and loss at the demise of their beloved Sovereign Lady, Queen Victoria, during whose glorious reign of sixty-four years, scientific work and original research, such as our Club aims to accomplish, have received unprecedented impetus". Quite so!

But Victoria was not the only recent loss mourned by the Club in the new days of the new century. In the Victoria Memorial edition, in fact, President Henry Ami laments the February 1899 "early demise of our friend and fellow member, the sweet poet of Ottawa, Archibald Lampman ....[whose] ardent love of Nature and all she teaches in lake, forest, in autumn, in winter, in sorrow, in comfort, led him into those numberless nooks and sequestered spots which enchant the eye, please the mind and entrance the soul" (Ami 1901).

Just to be sure that the readers not think the Club had become overwhelmed by anthropocentric concerns, Ami went on in his address to eulogize a major scientific personality ... the aforementioned Elkanah Billings who had played such an important role in the founding of scientific natural environment investigation in the Ottawa Valley in the first place. Ami further announced that the Club has commissioned a portrait of the late Mr. Billings and was donating it to the Geological Survey Museum (Figure 1).[7] Shortly after Ami's address, the Council established a committee to co-ordinate with "different societies affiliated with the Royal Society of Canada" lobbying of the federal government for the construction of a National Museum (LAC OFNC Collection, 13 February 1900). Was this the genesis of the undertaking which resulted in the completion and occupation of the magnificent Victoria Memorial Museum building in 1910-1911? In any event, the Club officers were clearly aiming for a balance between the scientific investigation of the natural environment and the encouragement/enhancement of public awareness of the importance of such concerns.

A growing OFNC interest in and emphasis on encouraging public awareness and appreciation of natural sciences is shown by the active promotion of involvement by the students and staff of the Ottawa Normal School (teachers college) during the early years of the 20th century. This was the dawning of "environmental education" in North America and the Club seemed enthusiastically involved, particularly through the school. At least five members of the OFNC Council worked at the school in this time, including Vice-Principal S. B. Sinclair. Sinclair served in various Club

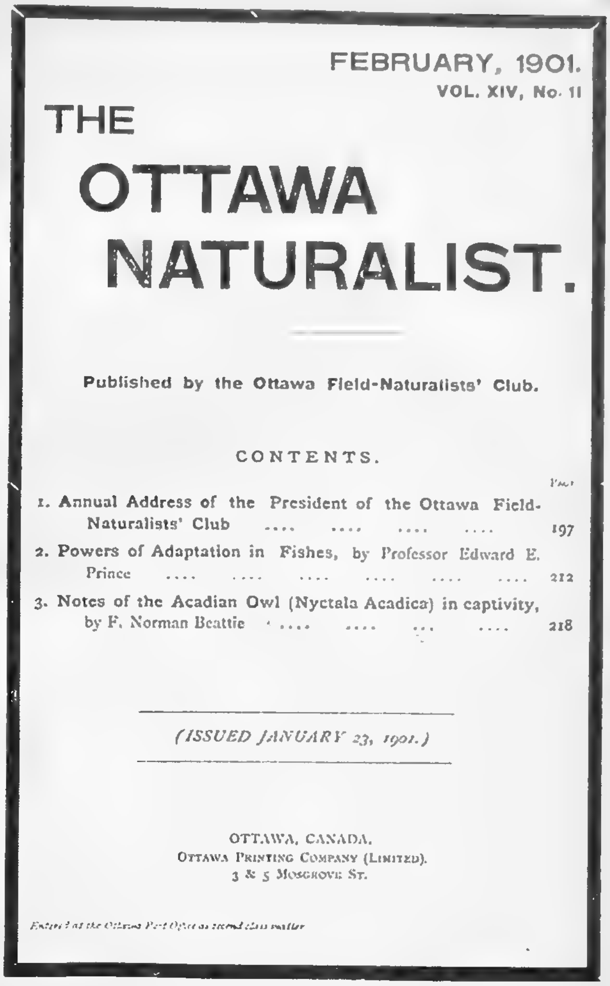
capacities during this period, including OFNC 1905-1906 President (Appendix 1).

Not everyone shared this positive view of environmental education within the Normal School and Ottawa public schools. A lengthy debate was held amongst key Club members early in 1905 on the difficulties and obstacles of this undertaking. In his characteristically direct way John Macoun declared "it to be his conviction that Nature Study would soon be consigned to the limbo of exploded educational fads" (Attwood 1905). Nonetheless, the Club remained formally involved in such school programs for years thereafter.

OFNC excursions also remained popular public events, with over 200 people attending each of the general excursions into the Gatineau Hills in May and September 1902; tickets were 30¢ for adults, 15¢ for children, including the cost of the day-long, chartered train trip (LAC OFNC Collection, 13 May 1902). Among the participants of the 6 September 1902 excursion was Normal School Vice-Principal Sinclair "who was accompanied by about 100 Normal School students" (LAC OFNC Collection, 6 September 1902). One might cynically question if all 100 would have been willing participants in their principal's venture.

By the early 1900s, however, the Club was not nearly so involved in original field-oriented research in the Ottawa Valley as it had been one to two decades before. There seemed to be a sense that "we pretty much know it all now" as research reported in the pages of *The Ottawa Naturalist* grew increasingly more national in scope. A greater sense of conservation concern was developing, however, with the first formal conservation action being initiated when the Council approved a motion by the Ornithology Committee for an OFNC petition calling upon the federal government to promote the preservation of shorebird-breeding wetland habitat in the newly established prairie provinces (LAC OFNC Collection, 7 April 1908). It was a tentative step (an article in that month's issue of *The Ottawa Naturalist* also provided a prescription for a "better" Timber Wolf poison [Anonymous 1908]). Nonetheless, it initiated a long history of conservation action and achievement for which the Club has been widely honoured and of which the Club can be justifiably proud.

Since its founding, the OFNC had elected a Librarian and maintained a natural history library. There were regular reports in Council minutes of titles of the incoming scientific literature received in exchange for *The Ottawa Naturalist* or as a professional courtesy to individual OFNC members. By 1904, however, it was becoming a problem due to the logistical challenge of housing and caring for the collection in donated space (LAC OFNC Collection, 15 March 1904). In 1906 the library consisted of "some 350 bound volumes occupying about 70 feet of shelf space" as well as many unbound volumes (LAC OFNC Collection, 26 February 1906). The collection seemed to be little used, however, as the members with significant scientific questions typically had access to the growing institutional libraries at the Museum or "The Farm" (as the research centre at the Central Experimental Farm was – and still is – known). Arrangements were made in 1909 to move the library into the Ottawa Public Library where it would be maintained as a stand-alone collection (LAC OFNC Collection, 22 June 1909). Predictably, the Ottawa Public Library eventually tired of the cost and effort of such an arrangement. Faced with no other realistic options for its maintenance, in 1917 the OFNC donated the collection to the OPL, asking only that such material be labelled as a Club gift (LAC OFNC Collection, 8 March 1917).[8] Curiously, the position of OFNC Librarian lasted longer than the library, being eliminated only in a constitutional change two years later (LAC OFNC Collection, 15 January 1919).


FEBRUARY, 1901.
VOL. XIV, No. 11

THE OTTAWA NATURALIST.

Published by the Ottawa Field-Naturalists' Club.

CONTENTS.

	Page
1. Annual Address of the President of the Ottawa Field-Naturalists' Club	197
2. Powers of Adaptation in Fishes, by Professor Edward E. Prince	212
3. Notes of the Acadian Owl (Nyctala Acadica) in captivity, by F. Norman Beattie	218

(ISSUED JANUARY 23, 1901.)

OTTAWA, CANADA.
OTTAWA PRINTING COMPANY (LIMITED).
3 & 5 MOSGROVE ST.

FIGURE 9. The *Queen Victoria Memorial issue* of *The Ottawa Naturalist.*

James Fletcher retired from the Council in the spring of 1905, after having filled almost every conceivable position in the Club and working for it in so many other ways throughout its first quarter century. The event passed with remarkably little fanfare. Such a low-key exit for such a pivotal figure was likely Fletcher's own doing, however, as indicated by the very

different reaction to his sudden and unexpected death on 8 November 1908.

Although moving along well with an active publication, excursions, and environmental education program, the Club was clearly devastated by the loss of Fletcher on both an organizational and, for many key Club people, a personal level. A number of Club founders and luminaries had died earlier, such as OFNC 1892-1895 President George Dawson (1849-1901), but no one personified the enthusiasm, idealism, and commitment of the Club as did James Fletcher. A memorial number of *The Ottawa Naturalist* was produced in January 1909, reproducing the many insightful and heart-felt tributes delivered by professional and personal colleagues alike at a special memorial event held on 1 December 1908. The presentations of Club co-founders R. B. Whyte and Will Harrington were remarkably emotional presentations under such stiff, proper Edwardian circumstances. Will Harrington's tribute in particular (Harrington 1909) is quite capable of tugging heart strings for contemporary readers a century removed from that time. With the exception of an unfortunately self-promoting speech by John Macoun, all contributors that night were clearly bursting to express their appreciation for the man, for his contribution to the Club and for his contribution to his chosen country.

Individual Club members were encouraged to contribute to a Fletcher Memorial Fund for the construction of a memorial drinking fountain to be placed near Fletcher's former work site at The Farm. It was quickly oversubscribed, having accumulated over $1800 by early 1910 when construction of the memorial began (LAC OFNC Collection, 15 March 1910). A bronze likeness of Fletcher was created by famous sculptor (and athletic community associate?) R. Tait McKenzie and affixed to the fountain. The fountain, with a descriptive plaque attached, was installed in 1911. It remains along the south side of the NCC Scenic Drive in the Central Experiment Farm immediately east of the Canada Agriculture Museum.

A memorial painting of James Fletcher was also commissioned with surplus funds from the Memorial Fund and hung in the Ottawa Public Library[9] early the following spring (LAC OFNC Collection, 12 March 1912). It was officially unveiled by the federal Minister of Agriculture, Sydney Fisher, who "specially dwelt on [Fletcher's] loveable qualities which had endeared him so much to all who came in contact with him" (LAC OFNC Collection, 19 March 1912).

It is likely no coincidence that a malaise seemed to settle over Club affairs in the following years. Few meetings of Council or Club excursions were conducted in the 1909-1911 period and discussions were held about reducing the workload associated with *The Ottawa Naturalist*, including publishing the journal only quarterly.[10] The Club operated at a deficit for the first time in 1910/1911 (LAC OFNC Collection, 21 March 1911). In late 1911 Editor James Macoun reported that the Club could no longer afford to publish monthly (LAC OFNC Collection, 18 December 1911).

There were calls for – and a dire need of – new blood in the organization and President Alexander McNeill suggested establishment of " … a junior branch for the boys. He referred to the success of the boy scouts but objected to the military spirit associated with it" (LAC OFNC Collection, 12 March 1912). Ironic words less than two years before the outbreak of World War I. Nothing came of this for many years, however, until the founding of the Macoun Field Club (see "Post-war Boom (late 1940s-1965)", below).

The Ottawa Naturalist seemed similarly to be somewhat unfocussed, publishing a relatively large number of paleontological papers and natural environment investigations and reports from afar but with the few local contributions increasingly confined to popular topics. A review article on the horrors of Poison-ivy allergic reactions provides an example, reminding any potentially afflicted reader that " … nothing is better than the old-fashioned lead and opium lotion …" to relieve the itching (Macnamara 1912).

The notable exception to this was the effort to develop an active environmental protection and bird conservation program, led by Gordon Hewitt (1885-1920). Hewitt was Fletcher's replacement as Dominion Entomologist (in 1909) and like him, was a dynamic, personable English immigrant (Criddle 1920). During his few years in Canada he played an important role in North American natural sciences and conservation matters, including being the lead Canadian official in the development of the 1916 Migratory Birds Convention, before dying at a tragically young age in the post-war influenza epidemic (Foster 1978). Likely being assisted by his socially prominent position as the husband of Prime Minister Bordon's niece, he successfully lobbied both the Ottawa Improvement Commission (forerunner of the National Capital Commission) and the Boy Scouts of Canada to become involved in enhancement of migratory bird habitat (LAC OFNC Collection, 17 February 1914). His crushing load of professional responsibilities, however, limited the amount of time he was able to put into re-energizing the Club, even during his tenure as President in the difficult war-time period of 1918-1919.

As with so many cultural, social, and technical institutions in Canada, the OFNC was devastated by events surrounding Canadian involvement in World War I. On top of their post-Fletcher era struggles, the burden of war-time logistics, costs, and priorities came close to destroying the OFNC. The Club ran deficits through the war years and for the first time in Club history, the steady rate of membership growth virtually stopped (Figure 7). A new focus and a new source of energy were desperately needed. They came in the form of another recent arrival in Ottawa, this one being a tall, quiet, bearded architect turned ornithologist from southwestern Ontario who would turn the OFNC into a national institution.

A National Role (1918-early 1940s)

Percy Taverner (1875-1947) didn't think much of Ottawa or Ottawa naturalists when he arrived in 1911 as the National Museum's first ornithologist (Cranmer-Byng 1996). Shortly after arriving he complained to a Detroit friend, "we have a club here, the Ottawa Naturalists, who are much on a par with the Detroit bunch. They have nice picnics every week but they are no place for you and me. The worst of it is that they have all kinds of direction with good men. Fletcher, Macoun, Gibson and the whole Geological Survey and that of the Experimental Farm, but they haven't evolved a single naturalist in their twenty-five years of existence. The only thing they have got is a publication that has a government grant and appears regularly and in which we can get publication any time. If not for that, the real students here would have let the whole organization die a natural death long ago". (LAC Taverner Collection, 29 April 1912).

Taverner's criticism was brutal and a bit unfair – but not by much. And to both his eternal credit and the benefit of Canadian natural sciences, he set about working with other like-minded rebels to shake the old outfit up and to make it – or at least, its publication – better serve the needs and opportunities of the contemporary naturalist and public communities. Fletcher, Martin, Henry B. Small, Whyte, and Harrington would have been proud.

Like Fletcher before him, Taverner maintained an extensive network of correspondents across Canada and the United States. Although allied on the OFNC Council with the likes of botanist James Macoun, long-time editor of *The Ottawa Naturalist*, entomologist Arthur Gibson (1875-1959), and herpetologist Clyde Patch (1887-1952), Taverner was inspired by his field-naturalist colleagues across the country to broaden the reach of the Club's publication. Early in 1918 he argued to the Council that "… it does not seem possible to support a worthy publication in a purely local field. Any such endeavours to be successful must enlarge its field. I therefore suggest that the pure local character of the periodical be removed by a change of name and propose The Field Naturalist" (LAC OFNC Collection, 26 March 1918).

Taverner, Macoun, and associates made the skeptical Council an offer they could not refuse. They promised it would mean no substantive change for local naturalists and would still accommodate more popular general public issues. Most importantly, they personally guaranteed to underwrite a huge expansion in membership in order to establish a secure, long-term financial base for the program. James Macoun, for example, immediately pledged to underwrite 100 new memberships; Taverner, Patch and anthropologist F. W. Waugh each took on 25 and archaeologist W. J. Wintemberg accepted responsibility for a further 15 (LAC OFNC Collection, 1 May 1918; 17 March 1919). How could the Council refuse such an offer?

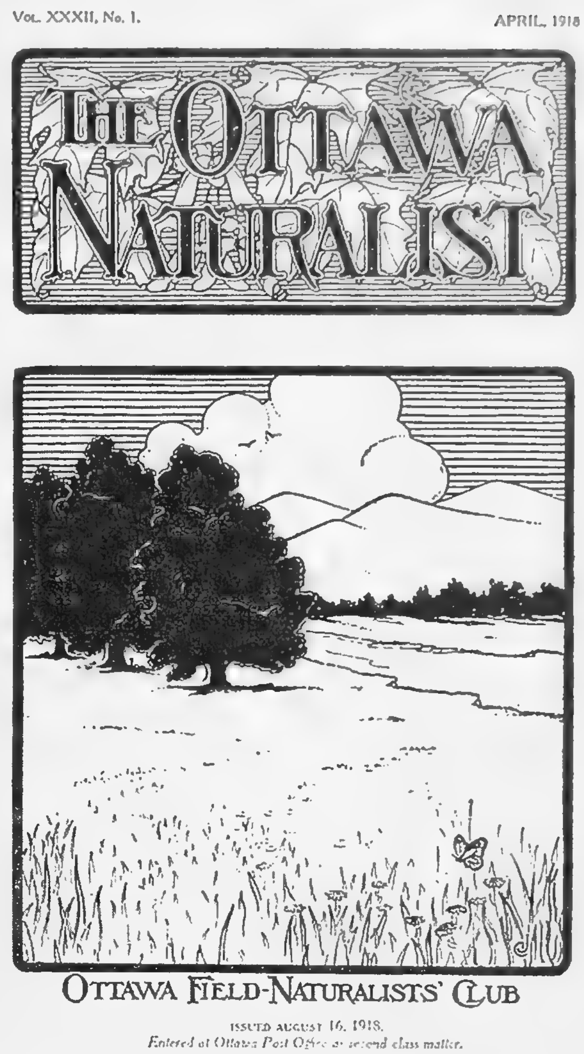


FIGURE 10. An issue of the last volume of *The Ottawa Naturalist* in 1918.

Taverner described the manoeuver to his mentor J. H. Fleming in August 1918 as something of a coup, "… a few of us got in control and overrode the conservatives … " (Cranmer-Byng 1986). He went on in the Fleming letter to say, "we hope to make it the scientific and nature study periodical of Canada" (LAC Taverner Collection, 10 August 1918). And indeed, by the following spring the mailing list had virtually doubled to over 540 names (LAC OFNC Collection, 17 March 1919). Taverner reported back to a skeptical Fleming in Toronto that "you are mistaken in believing that the change in name will not help *The Ottawa Naturalist*. It has helped already. The change in form can only be supported by increased subscriptions and we have to rely mostly on Canadians for this. The jealousy of anything labeled Ottawa throughout Canada is surprising" (LAC Taverner Collection, 10 April 1919).

The Canadian Field-Naturalist (CFN) was officially established by a motion from James Macoun (seconded by Taverner) at the OFNC Annual Meeting in March 1919. A change had already been made in April 1918 with a larger format and better paper (Figure 10),

graced by the attractive, if pastoral, cover illustration provided by Geological Survey of Canada artist C. E. Johnson. The new journal name was first used on the April 1919 issue. This cover illustration remained on each regular issue of the CFN until volume 59 (1945) when, without further explanation, it was removed in favour of the Table of Contents (LAC OFNC Collection, 3 March 1945).

The care and maintenance of the CFN became *the* primary issue and function of the Club. The underwriting of new subscriptions by the small group of 'friends' of the journal had a dramatic effect on membership numbers, the new levels of which persisted through the 1920s (Figure 6). This laid a strong, national foundation for the publication without which it seems unlikely the publication (and the OFNC) would have survived the dark days of the 1930s.

Another major publication initiative in that period was the first OFNC Special Publication, occasioned by the death of John Macoun. Upon the urging of his son, horticulturist and OFNC 1903-1905 President William T. Macoun (1869-1933), the Council agreed to publish the elder Macoun's autobiography (LAC OFNC Collection, 9 April 1921). Curiously, not since the Ottawa Natural History Society produced its occasional *Transactions* more than 50 years earlier had such a stand-alone publication been presented by the Ottawa naturalist community.

While a Memorial Fund was established to cover the $2500 costs of publication of the Macoun autobiography as well as a memorial portrait (again as with James Fletcher's portrait, created by Franklin Brownell), it apparently fell to William Macoun to make most arrangements (LAC OFNC Collection, 9 April 1921). This he did enthusiastically and efficiently, leading to an initial run of 2000 copies of the autobiography (Macoun 1922). Indeed, after the book was published, the 1922 OFNC Annual Report was deliberately altered to read that "the Club had co-operated with Mr. W. T. Macoun in the publication of the Autobiography of Professor John Macoun" (LAC OFNC Collection, 5 December 1922), suggesting that the Club may not have played much of a role in its development.[11]

The Macoun portrait was formally presented to National Museum of Canada Director William McInnis during the 1921 OFNC Annual Meeting which was held in the Victoria Memorial Museum, Macoun's last work place in Ottawa. It was accompanied by various speeches praising his extraordinary contributions to Canadian natural science (LAC OFNC Collection, 20 December 1921).

Other occasional publications appeared as Special Issues of the CFN through the 1920s. One was a treatment of the birds of Saskatchewan which included the first colour illustration to appear in the journal (Mitchell 1924) and another was a long essay on the natural resource potential of northern Canada (Kindle 1928), copiously illustrated by high quality black-and-white and half-tone plates. The latter, by paleontologist and OFNC 1927-1928 President E. M. Kindle (1869-1940), who had recently won a $1000 prize in a Canada-wide competition established by Sir William Price for the best article on this subject. This pattern of occasional Special Issues for larger, particularly significant or appropriate subjects has continued to the present day, recent subjects including the Taverner biography (Cranmer-Byng 1996) and a review of the orchid species of the Ottawa District (Reddoch and Reddoch 1997). Earlier long articles, like Fletcher's *Flora Ottawaensis* (Boivin and Cody 1955) or Hoyes Lloyd's review of the birds of Ottawa (Lloyd 1923; 1924), were often serialized over a number of issues.

Another special publication was called for in the 1920s. It was recommended to the Council by Geological Survey of Canada geologist J. B. Mawdsley that the Club produce " … a local scientific guide book of the region" (LAC OFNC Collection, 20 November 1929). The OFNC was indeed instrumental in seeing such a naturalist's guide produced, but that did not happen until nearly 60 years later (Brunton 1988).

Local programming became little more than occasional field outings and lectures during the late teens and 1920s, although efforts were made to get the Boy Scouts organization more involved during the early 1920s (LAC OFNC Collection, 26 March 1921). Nonetheless, Taverner's earlier unflattering portrayal of the Club's activity level was still more or less on target a decade later. This apparent lack of new energy and focus in the post-war years and early days of the Roaring Twenties was underscored by the deaths of a number of prominent OFNC pioneers and activists, men who had emphasized the need for and importance of local field activity. These included founders R. B. Whyte (1919) and Will Harrington (1918), as well as Gordon Hewitt (1920), James Macoun (1920), and John Macoun (1920).

National conservation issues, typically relating to the protection of particular animal populations, constituted the major non-publications subject of discussion of the Council in the 1920s and 1930s. On a number of occasions the Council passed motions for the Club to petition the federal government regarding such issues as improved national museum support or the protection of wildlife. This may have been awkward at times, since many of the people receiving and dealing with such pleas or critiques were Club members or professional associates of Club members. Senior government eyebrows may have been raised, for instance, when Editor Harrison Lewis (1893-1974) published a (prescient!) editorial in the CFN that was highly critical of apparent governmental support for increased commercialization of Canadian national parks (Lewis 1922). It has never been, after all, particularly judicious for active civil servants to publicly question

stated government policies or intentions. "Awkward", however, does not adequately describe the "Buffalo Crisis" of 1925.

The trouble arose when the Council directed that a letter be sent to the Department of the Interior protesting the proposed movement of Plains Bison of questionable health into the disease-free range of the last known herd of Wood Bison (LAC OFNC Collection, 28 February 1925). The protest letter was signed by OFNC President Hoyes Lloyd (1888-1978) and accompanied by a comparably critical Letter to the Editor which had recently been published in *The Canadian Field-Naturalist* (Harper 1925). Lloyd and the CFN Editor Harrison Lewis, however, were both employees of the Department of the Interior and their public criticism of their professional superiors was clearly not appreciated. Instructed to choose between continued federal government employment and their OFNC positions, both Lloyd and Lewis had little choice but to resign their Club positions immediately – to the apparent surprise and regret of the Council (LAC OFNC Collection, 11 April 1925). Lloyd became the first and only OFNC President forced to resign in mid-term, although he served the Club in many ways for decades thereafter and was awarded an Honorary Membership in 1965 in recognition of his contributions (Munro 1979). Curiously, the taking of this laudable, if perhaps somewhat naive position of principle, was publicly unreported until 2002. It is not even hinted at in *The Canadian Field-Naturalist* obituaries of either gentleman (Solman 1974; Munro 1979). Lewis, Lloyd, Harper and associates have been proven correct in their concerns regarding herd contamination, as the issue of appropriate Wood Bison population management in Wood Buffalo National Park is once again being hotly debated (Fuller 2002).

On a more positive note, the 50th anniversary of the OFNC was celebrated with an anniversary dinner on 19 March 1929 (erroneously believed to be the founding date – see "Founding Meeting", above), in which two of the few surviving founders (H. B. Small Jr. and Roger Davy) were the guests of honour. Other founders (participants in the 25 March 1879 founding meeting) still alive in March 1929 were L. H. Chrysler, W. Chesterton, and P. B. Symes (who died later that year).[12] The Club was doing reasonably well in early 1929, however, with a substantial surplus and a stable, adequate number of members to support its programs. If local activities were not undertaken at anything like the keen levels of years and decades before, the publication program seemed solidly and comfortably established and seemed to have achieved the national scope that Taverner, James Macoun, Lewis, and their associates had worked so hard a decade earlier to achieve.

The respite from difficult times was short-lived, however, as the Great Depression of the 1930s presented another severe test of the Club's staying power and its officers' mettle. Stripped down to basic functions – publishing the CFN and little else – the Club was enduring especially tough times, ushered in by dramatically falling membership in 1930 and a substantial budget deficit. There was a $728 swing in net revenues from the surplus of the previous year (LAC OFNC Collection, 11 April 1930). Membership would not again exceed the 1929 total of 549 until 1955 (6).

By the December 1932 Annual Meeting the OFNC was operating at a 20% deficit – and this only after drawing upon the Club's small Reserve Fund and securing a 12% reduction in charges from the CFN printer. The good news, though, was that excursion attendance was way up, with four spring field trips each averaging over 100 attendees. OFNC 1931-1933 President Charles Sternberg (1885-1981) concluded cheerfully "we feel our organization has stood up as well as others in the stormy times and we are, as a Club, now looking forward and ready to face brighter days as they dawn upon us" (LAC OFNC Collection, 6 December 1932).

It was not to be, of course. The Club officers were creative and flexible in finding ways of keeping things going despite the depletion of the Reserve Funds and low membership numbers. They agreed, for instance, to carry the 1934 membership of anyone who had been with the Club for five years but could not afford the $2.00 membership/subscription fee (LAC OFNC Collection, 9 January 1934). Local excursions were emphasized again (e.g., 10 were held in 1935) and while these did not appear to generate much in the way of new biodiversity information, they did offer a benefit and encouragement to local members. A re-emphasis on conservation matters was also expressed, especially by those working in National Parks and in federal migratory bird conservation offices, but no particular hands-on local initiatives were identified. The Council even decided to defer joining the newly established Federation of Ontario Naturalists which was dedicated to the objective of protecting natural areas and "native wildlife" (biodiversity) in Ontario (LAC OFNC Collection, 7 May 1936).

Despite the difficult times and reduced level of local activity, the 1936 Annual Business Meeting drew over 100 members, likely due to the attendance of Archie Belaney, a.k.a. Grey Owl (Dickson 1973) "… Canada's famous Indian naturalist and conservationist who spoke briefly on the need for immediate conservation action in Canada" (LAC OFNC Collection, 1 December 1936).

What sustained the OFNC through all the ups and downs of this difficult time was the special relationship of the Club with the community of biologists and scientists employed by the federal government, especially with those at The Museum (Geological

Survey of Canada Museum, then National Museum of Canada, now Canadian Museum of Nature) and The Farm (Central Experimental Farm, now various research initiatives within Agriculture Canada). Hall (1986) notes that over 30 employees of The Farm – the most notable being James Fletcher – served as officers, editors, and/or Honorary Members of the OFNC (Appendix 1). Twelve of those individuals had been OFNC presidents. A comparable or possibly even stronger commitment could be documented from The Museum, with Department of the Interior (Canadian Wildlife Service (CWS) and Parks Canada) personnel making a similarly important contribution to the operation and support of the OFNC. These people saw the Club in general and the CFN in particular as an important contribution to Canadian and North American natural sciences and to the conservation of the natural environment. They saw it (as many in such positions still do) as virtually their duty to participate. In an otherwise mundane 1937 debate on the question of possible reduction in the honorarium given to the CFN editor (from the princely of $90 established in 1928, to $50) as yet another cost-cutting measure, Harrison Lewis stated "… we are a scientific society and any one of us would carry on the work without salary for the good of the Club", to which Percy Taverner added " … the Editor works for the good of his science and not for wages …". The motion for a reduction in the editor's honorarium passed, by the way (LAC OFNC Collection, 10 April 1937), and was not increased again until 1947 (LAC OFNC Collection, 25 January 1947).

There remained a small group of Club officers throughout the 1930s and early 1940s who argued for more emphasis on a strong local program of lectures, excursions, and public education. This group was led by irrepressible biology teacher and priest F. E, Banim (1902-1979), statistician W. H. Lanceley (1893-1958), and technical editor Pauline Snure. These Club officials, also supported by botanist and OFNC 1935-1937 President Herb Groh (1883-1971), argued for the reestablishment of monthly lectures and a return to old time soirées as means of generating renewed interest and membership in the Club. They were successful in the establishment of a Flora and Fauna Committee to co-ordinate a renewal in the investigation and documentation of local biodiversity (LAC OFNC Collection, 28 October 1936). This latter committee ultimately had few results, although J. R. Dymond, selected as leader of the fish working group, presumably conducted at least a part the research which was the basis for his later *The Fishes of the Ottawa region* (Dymond 1939) in response to this initiative.

Snure was particularly forceful in the mid-1940s in taking on long-established, senior Council members like Hoyes Lloyd and, to a lesser extent, Harrison Lewis and Percy Taverner, and pushing successfully for such things as the establishment of an Excursions and Lectures Committee to co-ordinate services for local members (LAC OFNC Collection, 22 January 1944). The latter three – now old guard members – were the most vocal on Council in arguing for continued priority being placed on the important "national publication society" elements they had worked so hard to sustain through the difficult 1930s and into the early 1940s. Although their efforts only slowly bore fruit, Banim, Lanceley, and Snure (who served consecutively as OFNC President between 1944 and 1950)[13], were able to shepherd a measure of renewal of local naturalist activities in this period.

The at-times conflicting perspectives of local naturalist club and national scientific publication society simmered along, unresolved as national and world events (the latter years of the Great Depression, the commencement of World War II) effectively limited the ability of the Club to generate substantial new membership or financial resources. Despite the wartime limitation on materials and human resources, some Club local field investigations were initiated and the CFN continued to appear, albeit with many issues in 1941 and 1942 delayed by the printer's war work priorities. Not oblivious to patriotic opportunities themselves, in 1942 the Council responded to a request for the exchange of scientific literature from the Lenin Library in Moscow by offering a free set of The CFN from 1935 "until the close of hostilities … as a mark of our good will" (LAC OFNC Collection, 5 October 1942). For OFNC functions and programs, the World War II period was essentially an extension of the publications and membership subsistence efforts of the 1930s. Only as the war in Europe was winding down did the first signs of renewal and new potentials – such as increased membership – begin to appear (LAC OFNC Collection, 5 December 1944).

Post-war Boom (late 1940s-1965)

One of the first signs of the rebirth of local area activity within the OFNC came with publication of review articles on the birds and mammals of the Ottawa District in the latter years of World War II (Lloyd 1944 and Rand 1945, respectively), at least in part at the urging of local naturalist advocates like Banim, Snure and Lanceley. Although based largely on historic Museum data and/or the authors' observations, these review papers gave local naturalists the first comprehensive treatments of popular Ottawa District flora or fauna since Fletcher's 19th century vascular plant list (Fletcher 1888) and Lloyd's bird list from the 1920s (Lloyd 1923; 1924).

Almost coincident with, but much more important than this, was the tremendous post-war growth in the professional civil service in response to the needs of an expanding, prosperous post-war national economy. A new wave of young, energetic, natural scientists from all across Canada was arriving in Ottawa in the late 1940s and early 1950s, many soon joining and becoming involved with the programs and workings of the OFNC. Following the dark days of the Depression

and then the war, many of these individuals were keen to contribute both to the improvement of their recovering local and national communities and to the exploration and protection of Canadian natural biodiversity. In November 1946, for example, future Honorary members and important Club contributors Clarence Frankton (1906-2000) (Brunton 2003) and Jack Gillett joined the Club, followed the next month by long-time Business Manager of the CFN and future Honorary Member Bill Cody. Indeed, almost 150 new members joined the OFNC in 1948 alone (Snure 1978). Newly arrived natural science specialists were pressed by their OFNC veteran associates to join the Club; involvement in Club programs was almost an expected part of the job in those years (C. Frankton, personal communication).

This new wave of naturalists demonstrated something not seen since the early years of the Club's history – a keen enthusiasm for field exploration and discovery, and a desire to share that new-found knowledge with the naturalist community and the general public. Accordingly, the late 1940s and early 1950s were productive years for the documentation of Ottawa area biodiversity, as indicated by the richness of the specimen records from that time in the collections of The Museum and The Farm (personal observation).

Another major initiative of this period was the formation of the Macoun Field Club (MFC), a junior naturalists club sponsored jointly by the OFNC and the National Museum of Canada (Snure 1978; Baldwin 1978). Such an organization had been talked about since before the First World War, but nothing had come of it. Due to dedicated work by a large number of Club and Museum people, however, it was successfully established in 1948. The first MFC Committee Chairman was OFNC 1954-1955 President W. K. W. (Bill) Baldwin (1910-1979) (Figure 11) who set the initial tone and procedures which have stood up ever since (Soper and Bousfield 1982; Francis Cook, personal communication). The MFC has supported and encouraged the investigation and documentation of natural biodiversity by elementary and secondary school children in the Ottawa area through a remarkably rich program of lectures, workshops and most importantly, field studies, for over 50 years (Lee 1998). The work of Bill, Herb Groh (Figure 12) and David Maddox was particularly critical to this success in the formative years of the MFC. Many OFNC club members contributed time and even, in the case of Mary Stuart, access to their property for field trips (Figure 13).

The OFNC also undertook to generate greater public awareness of natural environment matters and to develop an additional stream of funding for the Club by arranging local sponsorship of Audubon Screen Tour presentations in Ottawa. These were professionally produced and well-attended illustrated lectures by speakers of the calibre of Roger T. Peterson and George M. Sutton (personal observation). They provided an important source of general public education on a wide range of natural environment topics in the days before specialty television channels or, indeed, television of any kind was available for most Ottawa households. It's not entirely clear who was the Club's lead on this program; Humphreys (1979a) suggests it resulted from Oliver Hewitt's circulation of an Audubon Screen Tour brochure in December 1947. The records of the minutes books, however, state that former Treasurer and future Honorary Member Ibra Connors (1894-1989) brought the issue before the Council for approval later that winter (LAC OFNC Collection, 21 February 1948). Regardless, until it was cancelled in 1959, the Audubon Screen Tours program was enjoyed by many thousands of Ottawans and generated considerable revenue for the Club (Humphreys 1979a).

A significant amount of Club revenue also resulted from the clearance of a mass of The CFN back issue orders which had built up during the 1941-1955 editorship of Harold Senn (1912-1997). Bill Cody and Clarrie Frankton spent weeks ferreting out and following up on years-old orders for The CFN back issues (C. Frankton, personal communications). The resulting revenue formed the seed funding which has grown into what now constitute very substantial OFNC reserve funds.

In the late 1940s and for the first time in OFNC history, the Club had its own field station. In 1949 A. E. (Fred) Bourguignon (1893-1968) arranged for a 10-year lease of a property at Beatty Point along the Ottawa River off what is now Grandview Road in Nepean. For a cost of $300 (assisted by a substantial donation of building materials), various Club members (most particularly, Fred Bourguignon) worked to construct a small wooden building which would serve as a base for OFNC field studies in the area. Beatty Point Lodge, as it was called, was officially opened on 24 May 1949 and served as a field investigation centre for almost 10 years. Encroaching urban growth, expanding road networks, and the proliferation of personal automobiles eventually made a single base of operations less useful for contemporary field explorations and the building was sold in the late 1950s (Humphreys 1979b).

Some members in the early 1950s wished to delve more deeply into particularly popular natural history subject areas in the Ottawa District. From this interest arose informal study groups such as the Fern Group, the Bog Group, the Trail Group, the Bird Group, etc. (Dill 1979; 1982), and later, the Native Orchid Location Survey. Consistent with the science-based approach of OFNC field investigation throughout its history, these study group participants did more than just explore interesting natural landscapes and share identification information amongst themselves. They documented significant findings in writing and/or with specimens. The records of the Fern Group, for example, were heavily relied upon for the production of a treatment of the ferns of the Ottawa District (Cody 1956). The Native Orchid Location Survey was estab-

FIGURE 11. Bill Baldwin, botanist at the National Museum of Canada and the first chair of the Macoun Field Club, at the meeting room provided by co-sponsor National Museum of Canada in the basement of the Victoria Memorial Museum Building together with early members Cynthia Millman and Nancy Fergusson, November 1950 (Macoun Club files, courtesy of Rob Lee).

FIGURE 12. Herb Groh, then just retired weed specialist at the Canada Department of Agriculture and a Past President of The Ottawa Field-Naturalists' Club, with Macoun Field Club member Nick Wickenden, November 1950. (Macoun Club files, courtesy of Rob Lee).

FIGURE 13. One of many Macoun Field Club trips to OFNC Honorary Member and long-time Macoun volunteer Mary Stuart's property near Packenham: Intermediate and junior groups, March 1969. Photograph courtesy of Rob Lee.

lished by E. W. Greenwood in 1966 and soon grew in scope beyond the Ottawa District, gathering a considerable body of orchid location data from volunteer contributors across Canada until the mid-1970s (Reddoch and Reddoch 1997).

With local natural history activities reaching levels not seen since the early days of the century, OFNC members felt the need for more timely and topical information through a forum which would help to "tie the members together" (LAC OFNC Collection, 28 February 1949). Appropriately enough, that initiative was approved by the Council at the same meeting authorizing the construction of the Beatty Point Lodge, underscoring the new-found enthusiasm for local activity. The first issue of the *Ottawa Field-Naturalists' Club Newsletter* was published in April 1949 under the editorship of Verna (Ross) McGiffin. It ran until 1967, providing timely notices of meetings and events and offering a forum for the speedy exchange of information and opinions on a wide variety of issues of interest to the local membership.

The Club reached its 75th Anniversary in 1954, though due to program delays, the occasion was actually celebrated in 1955 (Dill 1979). It was much more of a party affair than the low-key Founders' Tea and Club dinner held for the 50th anniversary back in 1929. The Club was profiled in the print media and a local department store provided a display window for an exhibit on the Club. The attention paid to the event generated the first formal demonstration of historical interest in the organization. Herb Groh, whose OFNC involvement dated back to the pioneer days of the Club and who had worked with both John Macoun and James Fletcher (Taschereau 1972), provided an anecdotal history of Club Presidents (Groh 1955). After all, he'd known almost all of them! Although some historical documentation of technical matters pertaining to the CFN's publication history had been produced (LaRocque 1931; Boivin and Cody 1955), this was the first public documentation of the personalities and events that had highlighted the Club's history.[14]

The CFN produced increasingly larger issues through this period, reflecting the greater volume and quality of original field work being conducted both locally and farther afield in the early to mid-1950s. This increased production, however, posed financial problems as publication costs increased 400% from the mid-1940s to 1953; Club income not quite doubled in the same period. Since it was felt that membership fees ($2.00) were as high as could be sustained, costs had to be reduced. Accordingly, after decades

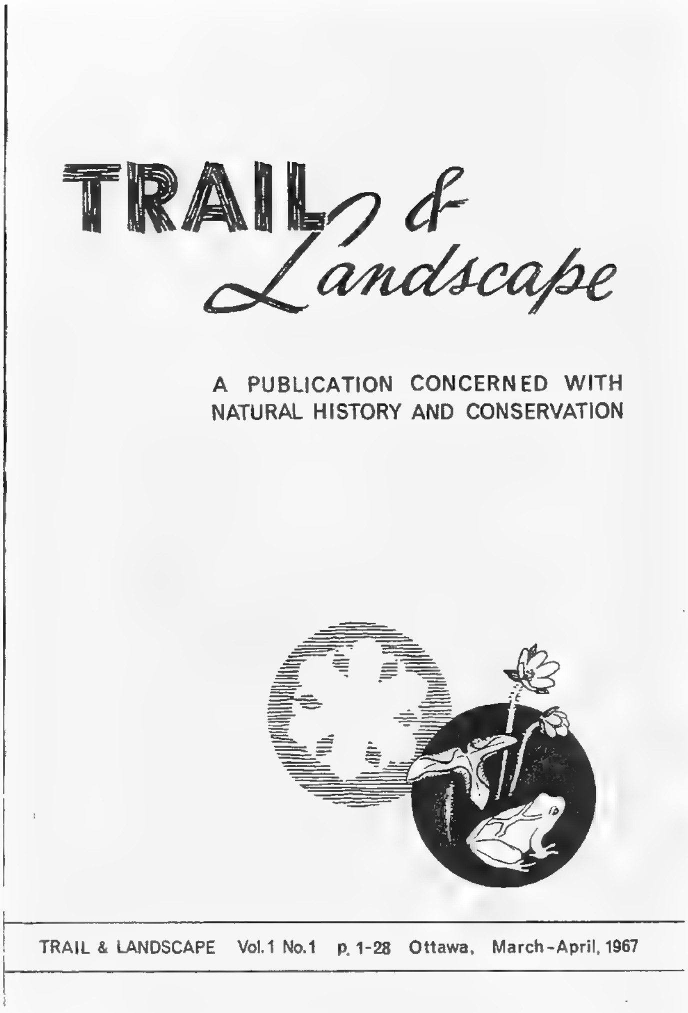


FIGURE 14. The first issue of *Trail & Landscape*, March-April 1967, a journal for regional observations and outings and Club events. The cover was designed by the first editor, Anne Hanes.

of debate on the matter, the journal was reduced to quarterly publication (from six issues per year) effective with volume 67 (1953) (LAC OFNC Collection, 20 November 1952). Publication production problems were seriously exacerbated by lengthy delays in getting into press, leading Publications Chairman and OFNC 1950-1952 President Walton Groves (1906-1970) to "express his deep regret at his inability to command the support and co-operation" of just retired editor Harold Senn (who had served 13¼ years) in order to pass on the editorship to incoming editor R. A. Hamilton (LAC OFNC Collection, 4 May 1956). By the end of 1956 the last issue of the 1955 volume had still not been produced. The Council decided not to pay out the editor's honorarium for that year until the volume was completed (LAC OFNC Collection, 13 December 1956). The crisis was resolved by a flurry of publication activity under the efficient new editor, however, with seven issues being published between February and September 1957 (LAC OFNC Collection, 30 September 1957)![15]

The Club continued to struggle financially despite the generally rosy economic picture in the country, as it also had, ironically, during the "Roaring Twenties". In the mid-1950s, for example, Treasurer R. J. Moore advised the Council "to go easy, especially keep Excursions & Lectures Committee under control" (LAC OFNC Collection, 29 February 1956). Walton Groves' assessment was even more brutal, stating that "many of the Club's activities have been crippled by the delay in publication" and by the need to publish so many issues in such a short time (LAC OFNC Collection, 30 September 1956). Despite the return to timely publication of the CFN, at the end of the decade Groves still reported that "the financial position of the Club continues to be very grave" at (LAC OFNC Collection, 1 December 1960).

Still, the OFNC managed a Special Issue of The CFN, Alice Wilson's *Geology of Ottawa* (Wilson 1956). It was likely only possible because Carleton University placed a pre-publication order for 1000 reprints (LAC OFNC Collection, 13 April 1956).

Before environmental conservation and the protection of natural biodiversity became major social and cultural phenomena in the Western World in the 1960s, the locally-focused elements within the OFNC had been gradually increasing the organization's level of involvement in such directions. In the early 1950s, for example, Harrison Lewis met with the Federal District Commission (FDC) to discuss how the OFNC could (and would) provide wildlife protection and enhancement consultation during Gatineau Park development. They also explored the idea of an OFNC field station space being provided in an expropriated Gatineau Park building (LAC OFNC Collection, 7 April 1951). An OFNC Gatineau Park Committee was formed under the chairmanship of OFNC 1960-1961 President Winston Mair and made various recommendations for wildlife habitat enhancement there. The Federal District Commission also asked the Club to be involved in the establishment of a Brewery Creek bird sanctuary in Hull (Gatineau), presumably in response to the high profile that site had received from former British High Commissioner Malcolm MacDonald's war time reminiscences in *Birds of Brewery Creek* (MacDonald 1947) (LAC OFNC Collection, 13 March 1952). Nothing came of that and neither FDC consultation was mentioned again after 1954 (LAC OFNC Collection, 15 December 1954).

Conservation priorities (late 1960s-early 1980s)

A forerunner of the OFNC Conservation Committee, called the Preservation of Natural History Sites Committee, was established in 1960 with Bill Baldwin as its chair and with locally-active members including biology professor Donald A. Smith, CWS biologist Vic Solman, geologist D. D. Hogarth and botanist W. G. Dore (1912-1996) (LAC OFNC Collection, 15 December 1960). One of its first ventures – opposing the proposed destruction of the vast Mer Bleue peatland in eastern Ottawa (it was to be used as a regional landfill!) – was highly successful. It led not only to

FIGURE 15. Members of the Traill Group near Pinks Lake 29 May 1965, one of the last outings before disbanding as a formal group. From left to right are Winifred Anderson, Ruth Resenel, Alice Frith, Sheila Thomson, Bill Thomson, Rowley Frith, Hue McKenzie, Elva MacKenzie, Anne Hanes and unknown. Photograph by Charlotte Dill. *Trail & Landscape* 16(2): 95 [1982].

protection of that magnificent natural area, but also to a series of ecological and biodiversity investigations of the wetland (Baldwin and Mosquin 1969). Donald Smith played a pivotal role in generating the necessary awareness amongst both the naturalist community and National Capital Commission (NCC) officials of the significance of the bog (Dorais et al. 1974). The protected area – now some 3 500 ha in size – is managed by the NCC for the benefit of its ecological functions and has been declared an internationally significant wetland under the Ramsar Convention on Wetlands (National Capital Commission 1996).

In this period local Club members and the general public benefitted from two birding columns in Ottawa newspapers, one in *The Ottawa Citizen* by Wilfred Bell and the other in *The Ottawa Journal* by the appropriately named John Bird. The latter weekly column, "Bird's-eye View", was particularly beautifully written, accurate and insightful. It emphasized the growing level of birding activity in the Ottawa Valley and offered a timely (unofficial) bulletin board of OFNC and conservation events (McNicholl 1994).

Certainly the most important single occurrence for the local Club element in this period was the establishment of *Trail & Landscape* (T&L) (Figure 14). As expressed by the then CFN editor Theodore Mosquin, it was to be "a newsletter as well as contain[ing] articles of wide appeal in the conservation field" (LAC OFNC Collection, 5 January 1967). The existing OFNC Newsletter wasn't offering sufficiently comprehensive local coverage, nor could it satisfactorily accommodate the documentation of local conservation-oriented natural environment investigations which were increasingly being undertaken by Club members. T&L was an immediate and astonishing hit, not only satisfying a need of active local Club members but generating a huge, unprecedented increase in membership (Figure 6). Anne Hanes (1925-1981) was appointed as the first editor and exercised these duties superbly through 13 volumes (1967 to 1979), always encouraging environmental conservation themes wherever possible (Greenwood 1980).

Two subsequent editors, Joyce Reddoch (from 1980 to 1989) and Fenja Brodo (from 1991 to 1992 and 1993 to 2001) expertly supervised and directed the development of long runs of the publication. Reddoch's term was distinguished by the production of a number of large review articles which she solicited for both their intrinsic natural history value and their importance as reliable references for various conservation applications thereafter. A number of these, such as the reviews of Ottawa District amphibian and reptile species (Cook

1981, a revision of an earlier series in 1967 solicited by first editor Anne Hanes) and butterfly species (Layberry et al. 1982), continue to be locally referenced, as do all of the natural areas documentation published in T&L. The Club and its members have also been well served by other editors of *Trail & Landscape*, Elizabeth Morton (1990), Bill Gummer (from 1992 to 1993) and Karen McLachlan/Hamilton (from 2001 to the present).

Trail & Landscape quickly became *the* contemporary source for information on local natural environment issues. It has provided an ideal bridge between the recording of natural environment information for its own sake and in directing and assessing conservation priorities (Brunton 1986b). To some, the timeliness and thus effectiveness appears to have suffered, however, after a decision to reduce the publication schedule, for manpower and economic reasons, from five issues/year to four, starting with the 1988 volume. The subsequently reduced publication frequency and fewer total pages have coincided with a substantial reduction (by almost half) in the number of articles with direct conservation applications.

The huge increase in membership and higher profile of conservation and field-oriented activities in the late 1960s may have set too hectic a pace for some longtime Club stalwarts who had been more concerned with the national publication role. Hoyes Lloyd resigned from the Council at the end of 1967, stating that he felt it inappropriate as an OFNC Honorary Member to also serve as a Club director (LAC OFNC Collection, 6 June 1967). There is no such limitation on Honorary Members, however, and a number have continued to serve on Council with distinction for many years. Notable in this regard is 1979 Honorary Member Bill Cody, who has served *continuously* on Council since December 1947, shortly after becoming The CFN Business Manager earlier that year (LAC OFNC Collection, 21 May 1947). And similarly impressive is the contribution of Frank Pope, who has served on Council continuously since 1980 and has occupied the positions of Corresponding Secretary (three years), Treasurer (six years), Vice-President (one year) and President (an unprecedented six years) (Appendix 1).

The Canadian Field-Naturalist underwent a significant reconfiguration in January 1970, introducing a new size, format and appearance not just to improve its look but "to [make] its content as relevant as possible to the natural history needs of our time" (Mosquin 1970). And by "relevant", Editor Ted Mosquin meant strongly conservation oriented. That first issue was graced by a photo with a Timber Wolf – the contemporary symbol of wilderness protection – crossing a snowy landscape. The issue contained both a variety of articles on Canadian endangered species and a directory of conservation organizations in Canada. Conservation applications of carefully-researched ecological and natural diversity investigations have been a hallmark of The CFN ever since.

Both as OFNC 1969-1971 President and editor of the CFN from 1967 to 1972, Mosquin was at the forefront of efforts to enhance the level of OFNC conservation action and to engage both the membership and the general public in this. OFNC 1971-1972 President Sheila Thomson and OFNC 1972-1975 President Irwin Brodo were similarly motivated conservation voices in the OFNC, the three of them working together to persuasively direct Club environmental protection initiatives. Mosquin initiated a series of at times hard-hitting and at times controversial editorials (not the last we were to see in the CFN!), challenging Club members, the larger naturalist community, and public decision-makers to be more effective in protecting natural environments in Canada. In 1972 he resigned the CFN editorship to take on the challenge of founding editor of the Canadian Nature Federation's *Nature Canada*.

The infectious enthusiasm, environmental passion and unquestioned technical expertise of these three activists in concert with other Club leaders of the day such as OFNC 1963-1966 President George McGee (1909-1991) and OFNC 1967-1969 President Hue McKenzie, were an inspiration to a whole generation of new Ottawa-area naturalists (personal observation). For us newcomers, they transformed the understanding of the study of the natural environment from a seemingly slightly idiosyncratic, individual endeavour undertaken for personal entertainment to a meaningful – even important – and highly integrated calling. What a revelation!

The growing commitment to natural environment conservation in the late 1960s and early 1970s saw the re-energizing of OFNC Council and membership support in this area. At the urging of Ted Mosquin and Ed Greenwood and recognizing that the Preservation of Natural History Sites Committee was not broad enough in its mandate, in early 1967 the OFNC established the Natural Areas Committee to coordinate original field conservation research and to actively search out potential natural reserve sites in the Ottawa Valley (LAC OFNC Collection, 10 April 1967). By 1970, the committee was undertaking a broad program of local field investigations and had provided a basis for the identification of significant natural areas in the Regional Municipality of Ottawa-Carleton's 1974 Official Plan. So significant was the role and mandate of this group that the Natural Areas Committee was soon being promoted as the most significant of Club committees (LAC OFNC Collection, 8 December 1970). Increasing demand for input into various conservation issues both locally and beyond, resulted in the establishment of the Research and Briefs Committee (1972-1973), which in 1974 was combined with the Natural Areas Committee to form the Conservation Committee. This committee continues to play an integral role in OFNC and community affairs to the present day.

The OFNC Centennial in 1979 understandably brought forth a great deal of interest in the history of the Club in particular and of the naturalist community of Ottawa in general. *Trail & Landscape* provided the major vehicle for sharing this information amongst the local membership. Events culminated with a banquet intended to be on the exact 100th anniversary, but as with previous celebrations, it was erroneously held on 19 March (Reddoch 1979a), not the actual centennial date of 25 March.

The increased interest in the historical record generated by the Centennial year encouraged a new appreciation of the designation of OFNC Honorary Members. These had been given out only irregularly over the years to honour lengthy, significant service to the OFNC or Canadian natural sciences. Although honorary memberships have been awarded more regularly since 1971, the Centennial Year saw a new focus on this acknowledgment of such exceptional contributions (Brunton and Gummer 1987).

The conservation initiatives of the 1970s and early 1980s saw a resurgence of more systematic field examinations of uncommon and ecologically significant habitats in the Ottawa Valley such as fens, rivershore communities, and relict woodlands (Dugal 1978; Reddoch 1979b; White 1979). Publication of the first complete, annotated checklist of the vascular plants of the Ottawa District also reflected this knowledge (Gillett and White 1978) and contained many of the records newly discovered by Club members.

That burst of new knowledge and energy demonstrated that suggestions in the early years of the 20th century that our knowledge of the natural environment of the Ottawa area was all but complete, were badly incorrect. Our understanding of native biodiversity and of the ecological systems supporting it requires continual inventory and evaluation to enable effective protection and maintenance of this natural heritage.

The Club's conservation activities in this era, led by activist presidents Roger Foxall and Roger Taylor between 1978 and 1982 and by such energetic members as Loney Dickson, Allan Reddoch, Joyce Reddoch, Albert Dugal, Stephen Darbyshire, and David White, covered an amazing spectrum and exhausting number of subjects. These ranged from a campaign for a conservation area system in the Region of Ottawa-Carleton (now city of Ottawa) to prevention of the importation of Raccoon-dogs into Canada, and from the prevention of 1988 Winter Olympic facility development within Banff National Parks to consultations with federal government officials on ecological requirements in Gatineau Park and National Capital Greenbelt planning.

FIGURE 16. Excursion of Ottawa Field-Naturalists to the Rideau Trail in October 1979 (photograph by C. Beddoe). Contrast with Figure 9. Long-time member Mary Stuart is second from left.

The Club hosted the annual meeting of the Federation of Ontario Naturalists in 1983, establishing a successful program format that was followed by subsequent provincial gatherings for years to come. The OFNC again successfully hosted the provincial organization's annual conference in 1993 (Pope 1993).

A more whimsical contribution is to wildlife conservation initiated in this period was the "Seed-a-thon", a fund-raising effort whereby sponsors pledge a particular amount for every species observed on a particular day by a particular birding team, to be applied towards the cost of supporting a network of OFNC public bird feeder stations. Initiated by the Birds Committee on the suggestion of long-time OFNC member Violet Humphries in 1981 (personal communication), this was one of the first of what now are commonplace fund-raising events across Canada (Brunton 1981).

There was a human cost to all this activity, however, and many of the lead Club personnel in these matters eventually were called away by the mundane but critical matters of family and careers, moving on to other things and/or were simply exhausted by it all. This was exacerbated in the later years of the 1970s and into the 1980s by new pressures on the time and resources of professional research staff within the federal public service, reducing their availability and energy for involvement in such initiatives as local conservation and research. Only three OFNC presidents since the mid 1970s (D. F. Brunton, R. John and E. Zurbrigg), for example, were professionally involved in natural environment investigation or management (Appendix 1).

One of the most satisfying conservation ventures of recent decades has to be the effort begun in the early 1980s to save the massive, Provincially Significant Alfred Bog east of Ottawa (Cuddy 1983) from destruction by agri-business interests. This battle saw the Club purchase conservation land for the first time (in 1982) so as to have legal standing in the fight to secure proper protective zoning. It was a long and difficult effort but with the effective leadership of OFNC President Frank Pope, considerable financial and material contributions from numerous individual members, and the critical involvement of the Nature Conservancy of Canada, the entire wetland was saved and is now either in protective public ownership or zoned as parkland (Pope 2002).

The primary national contribution of the OFNC continued to be led by the publication of the CFN, although as noted, direct involvement in national-scale conservation issues was common enough in this period. Despite a continuing and perhaps even enhanced national/international status and production standard, however, the seemingly unanswerable question of how national or local the journal should be was raised again in a series of editorials in the late 1970s. The appropriateness and credentials of a citizen-based ("amateur") organization directing the affairs of the journal was severely criticized by Lorraine Smith, Editor 1972-1981, who suggested that "the burden of being accountable to the scientific natural history community for a national journal … may now be more than this local club should retain." [The days of calling the OFNC a "scientific society" were truly gone!] "Therefore… if the journal's reputation is not maintained and there is no move for a change in publisher, I challenge those who want a top-quality Canadian natural history journal, such as *The Canadian Field-Naturalist* is now, to initiate a new journal" (Smith 1981). These comments do not explain, however, how the OFNC managed to maintain and enhance such a fine journal for so many years.

After much discussion, consultation and review by an Ad Hoc Committee on OFNC Publications composed primarily of scientific specialists, the OFNC Council approved (8 December 1982) a new Publications Policy to guide the CFN and other Club publications (Bedford 1983). The Policy reiterated the Club's continuing, century-long commitment to the scientific integrity and high technical standards of the CFN, as well as the Club's intention to have the journal remain the official publication of the OFNC.

Francis Cook assumed editorship of the CFN from 1962 to 1966, and again in 1981, and has guided the journal to the present day with a steady and dependable hand, introducing important innovations such as the publication of Canadian status reports for candidate endangered species. There has been a great increase in the amount of material published in each volume during Cook's tenure (volumes averaged 756 pages over the five years ending in 2002). In the face of the many complications in the publication process, the timely publication of some issues has not occurred. Scientific and technical quality has never been sacrificed, however. The 28 volumes edited by Cook represent by far the longest and most prolific service of any CFN editor in the 124-year history of the publication, exceeding by more than a decade the tenure of the next longest-serving editors, Harold Senn and Arthur Gibson (Brunton 1986a).

Contemporary Times and the Future (mid-1980s to date)

James Macoun, Percy Taverner and other "nationals" who worked so hard to enhance the mandate, effectiveness, and reach of *The Canadian Field-Naturalist* would be relieved to see that the publication has achieved the solid reputation, steady production, and high scientific standards they hoped to see. An interesting expression of that long-term contribution and durability is demonstrated in the number of original descriptions (diagnoses of new taxa) which have occurred in the pages of the CFN. Over 730 have been published in the first 100 volumes (Brunton 1987).

The level of field-oriented investigation of the Ottawa Valley natural environment that was so productive in the 1970s and early 1980s, however, has been dras-

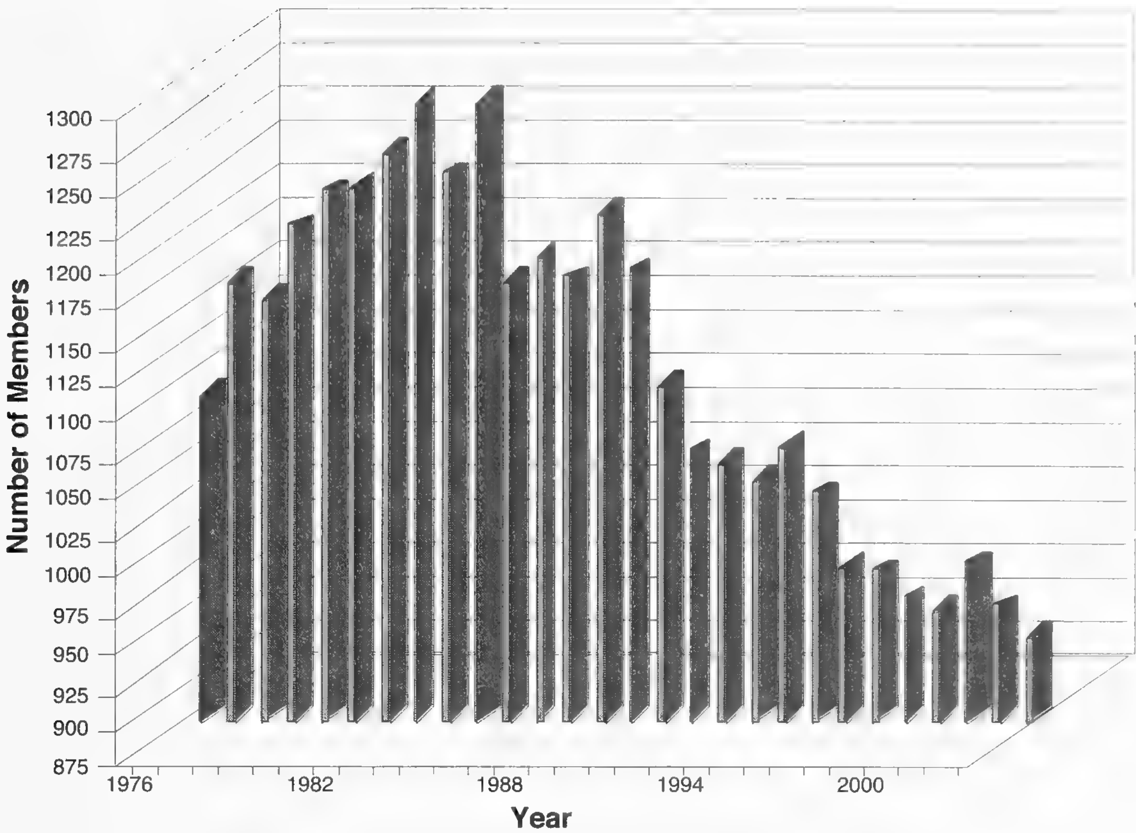


FIGURE 17. Ottawa Field-Naturalists' Club membership trend 1975-2003. Numbers of institutional subscribers to *The Canadian Field-Naturalist* were not calculated within membership totals nor reported separately in Annual Reports after 1971. A 1975 reorganization offered individual members (reported to total 1371 that year) the opportunity to be only non-voting subscribers to the *The Canadian Field-Naturalist*, dramatically reducing the OFNC membership total reported for 1976 (Erskine 1977) [Individual and institutional subscribers were reported separately in the Annual and Editor's Reports for *The Canadian Field-Naturalist* in each volume]. Absolute membership numbers prior to 1976, therefore, are not directly comparable to these of subsequent years (from OFNC Annual Reports, 1975-2002).

tically reduced. The appearance of substantially fewer area inventories and record documentation articles in *Trail & Landscape* reflects that trend. This may be part of an unfortunately strong North American perception in recent decades that continuing, original field investigations are of less importance than in previous times. T&L remains, however, an important and highly relevant source of environmental news and natural environment documentation.

Programs intended to actively involve the participation of local members have remained an important part of the OFNC. Dozens of field outings, lectures and special events are undertaken each year involving a diversity of well-informed leaders and speakers. For decades the Club's Excursions and Lectures Committee has crafted an interesting and instructive program that contributes greatly to the enhancement of members' skills and to their enjoyment in the field. While field investigations focus on both familiar and exotic localities throughout the Ottawa District and the Ottawa Valley, the Club does not confine itself to this area. The spring "migration" of a bus load of OFNC members to Point Pelee National Park, for example, has become a popular biennial birding event since the 1980s.

This is important stuff. The majority of Club members are locally based and most of us are involved, first and foremost, because we enjoy exploring and learning about our natural world. Providing support for scientifically important undertakings such as the publication of the CFN and the protection and preservation of important natural landscapes, is a valuable additional membership benefit. Membership in the OFNC remains an easy and enjoyable way for individual citizens to support greater understanding of, and protection for, important natural landscapes and features in the Ottawa Valley and beyond.

A noticeable change in the role of the local Club in regards to its community has occurred in recent years. The OFNC is much more integrated into environmental decision-making at a municipal and provincial level than it has been at any time in its past. It has become, in an sense, an ecological consultant to that community. While such a role requires seemingly endless attendance at meetings and reduced time for core field work, it has provided many excellent opportunities for Club representatives to bring accurate ecological information into the discussion of an issue at an early and effective stage of the decision-making process. A

cynic might say that the Club has become somewhat bureaucratized; an optimist would suggest that the Club now more frequently has a seat at decision-making tables across the National Capital Region. It is important to note, for example, that it was through this period that the final protection of the important Alfred Bog natural area was achieved.

Another very positive achievement of the last decade was the establishment of the Louise de Kiriline Lawrence Conservation Action Fund in 1994, founded with a generous bequest from the estate of that outstanding and eloquent field naturalist, Louise de Kiriline Lawrence (1894-1992) (Ainley 1994). It is sustained by further donations and by the profit from the sale of particular OFNC products such as the "Natural Areas" book (Brunton 1988). The fund provides for "strategic and timely expenditures towards the conservation of natural areas" in the Ottawa Valley (Anonymous 1994).

A continuing interest for many Club members is the Fletcher Wildlife Garden (FWG), established in 1987 in degraded woodland and regenerating agricultural land on National Arboretum property near the Rideau Canal. With the active cooperation and assistance of Central Experimental Farm (Agriculture Canada) personnel who are responsible for land management here, the Fletcher Wildlife Garden volunteers have transformed the site with native plantings, the creation of a pond and through public interpretation. The objective is not only to produce on-going, evolving habitat restoration but to demonstrate suitable wildlife-friendly landscaping and gardening practices for National Capital residents and visitors alike – to be "a model for urban gardeners" (Conservation Committee 1987).

These are all positive features. A disturbing trend in Club affairs, however, has been declining membership over the last two decades (Figure 17). Perhaps not coincidentally, Club membership peaked ca. 1982 to 1985, at the end of the period of greatest conservation-oriented activity. The local membership decline is seemingly in tandem with the decline of original field-based investigations. Nonetheless, the number of OFNC members remains substantial – the Club is still probably the largest regional natural history organization in Canada – but the downward membership trend needs reversing (Figure 17).

The reasons for this decline in participation are unclear. It seems unlikely to be attributable to the ready availability of up-to-date, comprehensive natural environment data on the World Wide Web since the membership decline began well before such technology was widely available. It may, in part, be a function of some wider, societal disinterest in hands-on involvement with citizen-based, research-oriented groups. Whatever the reason(s), the decline has been substantial and if it continues, will undermine the financial security and effectiveness of the OFNC.

Since the 1990s the digital world has had as dramatic an impact on the OFNC as it has on so many facets of contemporary Canadian life. We are only just coming to terms with its potential benefits and challenges. The OFNC's impressive web page (http://www.ofnc.ca) has allowed for rapid internal communications amongst Club officials, committee members and conservation partners, and for the posting of information and timely news items. Digital communication is only the latest expression of the Club's commitment to education of our membership and of the general public in regard to important natural environment features, needs and opportunities. The importance of the Club's educational programs has been a major theme throughout OFNC history and is expressed in the mission statement of the organization (see frontispiece of this issue). There is every indication that it will remain so into the future.

It is not yet clear how the Club will move forward from this foundation of established programs and resources in order to stay informed, relevant – and solvent – into the future. That's not a new challenge but is one that must be answered by *each* generation in response to the circumstances and opportunities of their day.

Some things are clear. For one, the Club needs to re-establish a higher level of field-oriented investigation amongst its membership. This will not only maintain and develop the skills and interests of present members but also inspire and generate new members. Accurate and timely field investigation and documentation are essential foundations for the maintenance of the high level of technical credibility that the Club has earned over the years. Continuing to do our homework, getting the facts straight, and presenting such information in a defensible, objective manner are the keys to maintaining and enhancing the OFNC's impressive record of conservation achievement.

As with any organization, regardless of how venerable, the OFNC must also continue to re-examine what it provides for the individual member. This is perhaps even more critical in an era with an unprecedented number of electronic diversions competing for the attention of both members and partners alike. Will the traditional superb program of excursions, lectures, and publications be enough to inspire and encourage a growing, involved membership? Do the new technologies of *our* time offer the same manner of new opportunities that technologies like the railway train, electric lighting, the automobile, and the airplane offered earlier OFNC members? They surely do.

What I hope is a clear message from this review of the long, remarkably productive journey of Ottawa naturalists is that the OFNC is not a static, hard-and-fast "thing". It is a community, an association of like minds that aims to explore and celebrate the magnificent natural world of the Ottawa Valley and of Canada. And as with any community, we in the OFNC have

FIGURE 18. Record service to *The Canadian Field-Naturalist*: Left: Francis R. Cook, Editor 1962-1966; Associate Editor (Herpetology) 1972-1981; Editor 1981-present; right: William J. Cody, Business Manager 1948-present. 25 August 2004. Photo courtesy Ron Bedford.

and have had the benefit of the skills, insight, and inspirational leadership of numerous individuals and groups over the years.

In weak times and strong, the common thread that has bound Ottawa naturalists since 1879 – indeed, since 1863 – is an overwhelming desire to contribute to the protection and enhancement of the natural features and values that make this place so special. At the end of the day it comes down to the fact that James Fletcher, Frank Pope, Percy Taverner, Sheila Thomson, Edward Van Cortlandt, Herb Groh, Gordon Hewitt, and the rest of us are not that different … we're all just Ottawa field naturalists.

Acknowledgments

The daunting challenge of reviewing a manuscript of this nature was undertaken in a timely and helpful manner by a team of naturalists well familiar with the OFNC and OFNC personalities. These reviewers were Ron Bedford, Bill Cody, Francis Cook, Karen McIntosh, Elizabeth Morton, Frank Pope and Joyce Reddoch. They added much to the effort and I gratefully acknowledge their input. I remain, however, fully responsible for any errors or omissions which may have escaped their sharp eyes. Frank Pope and Francis Cook provided additional factual input throughout the development of the manuscript. This review has also benefitted from the innumerable discussions (and debates!) I have enjoyed with Francis Cook over the last 25 years on numerous subjects related to the history of the OFNC and to the study of Canadian natural sciences. Ron Bedford, Frank Pope, Joyce Reddoch, and Rob Lee (present chair of the Macoun Field Club) were instrumental in obtaining many of the illustrations employed in this article. Rob Lee and Joyce Cook scanned several of these. I am happy too, to acknowledge two other important players in this effort. First is the late Herb Groh whose clipping file on OFNC personalities and whose interest in the Club's past inspired my own curiosity. The other gratefully acknowledged is the staff at the Library and Archives Canada (formerly the National Archives of Canada) who so efficiently and pleasantly facilitated my research with the OFNC collection and related files held within the walls of that national treasure.

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END NOTES:

1 **Number 1** (un-numbered), Braddish Billings' Ottawa vascular plant list (Billings 1868) was published between March and November 1868; **Number 2** (numbered), 500 copies of Sir J. A. Grant's examination of the surficial geology of the Ottawa Valley (Grant 1868) were published December 1868; **Number 3** (numbered), Thomas Wily's discussions of swallows (Wily 1869) was published December 1869 (LAC OFNC Collection, 10 December 1869; Dore 1968).

2 Much later, Henry Ami reminiscing about events leading up to the formation of the Club described "... how the Ottawa Club originated from the Epping Forest and Field Club, and later Ottawa Naturalists Club ..." (LAC OFNC Collection, 2 February 1924). Ami may, however, have been referring to names applied to informal groupings of field associates, such as the Fletcher, Harrington et al. group which conducted field work together in the Billings Bridge area in the late 1870s (Harrington 1909). There is no further mention of these groups in OFNC records by any of the individuals who, unlike Ami, were actively involved in the formation of the Club.

3 Later, R. B. Whyte erroneously reported this as occurring on 19 March 1879 (Whyte 1880). He may have been referring to an earlier preliminary meeting or to the date of the OLSS Council meeting where Fletcher and Henry Small Jr. obtained an expression of the co-operation and assistance from the parent organization, rather than the formal organizational gathering. Being documented only one year after the fact and by a Club founder and the originator of the idea of the OFNC, this error would quite understandably be accepted as fact and was repeated for over 100 years as the formal starting date of the OFNC (e.g. Groh 1955; Taylor 1979).

4 Relations between The Ottawa Field-Naturalists' Club and The Ottawa Literary and Scientific Society appear to have been strained on at least several occasions in the following years. In his 30 November 1886 Inaugural Address, for example, OLSS President W. P. Anderson complained that the OFNC (of which he was a founding member and had been the Treasurer for the previous three years!) was "antagonistic to the Ottawa Literary and Scientific Society" (LAC OFNC Collection, 3 December 1886). The OFNC and OLSS councils individually discussed the problem, the OLSS Council subsequently stating that they would consider " ... any proposition which the field Club may wish to make looking for a change in the relations between the Club and the Society but that a joint meeting of the two Councils cannot conveniently be arranged ..." (LAC OFNC Collection, 14 January 1887). Although no such joint meeting or other formal Club action resulted, the OFNC Council continued to meet in the OLSS museum until March 1890. That was despite another minor dust-up in 1889 concerning the OFNC's offer to cover some of the public lecture programming required of the OLSS in order to maintain its Ontario government grant (LAC OFNC Collection, 6 November 1889).

5 The involvement of women in the OFNC was very much promoted in these early years – in a patronizing if sincere way. The launch of *The Ottawa Naturalist* was accompanied by a special plea for the involvement of women ... "especially will be ladies welcomed to our ranks, and every effort will be put forward to make the excursions and soirees pleasant as well as instructive" (Harrington 1887). At the March 1888 Annual Meeting "... a discussion ensued as to the eligibility of ladies as officers, and the desireability of having some on the Council. Professor Macoun gave notice that he would at the next General meeting of the Club move that the executive Committee consist of six members, three of whom shall be ladies" (LAC OFNC Collection, 20 March 1888). This was accomplished by a Constitutional amendment in March 1890. Margaret A. Mills became the first female OFNC Officer when "Miss Mills" was elected Second Vice-President in 1892 (LAC OFNC Collection, 15 March 1892). She was not present at the meeting, however, and was apparently not agreeable to her election, as she resigned effective the next Council meeting 9 days later (LAC OFNC Collection, 24 March 1892), but stayed on as a Club member for several more years.

6 "This [Ottawa] District was then [1880] understood to mean a radius of about twelve miles from the City of Ottawa ... latterly, however, with the general consent of the botanists of the club, this radius has been extended to about 30 miles ..." (Fletcher 1888). The Ottawa District boundary was metricated in 1981 to a 50 km radius circle centred on the Peace Tower of the Parliament Buildings (Anonymous 1981), including landscape within both southeastern Ontario and southwestern Quebec.

7 The portrait hung for many years in the Geological Survey Museum (later, National Museum of Canada). It now can be seen on display in the Logan Gallery of the Geological Survey of Canada headquarters on Booth Street in Ottawa.

8 The saga of the OFNC library does not end there, however. In 1948 the Ottawa Public Library (OPL) reported to the Club that they had discovered "... the old library of the Club, now deposited in a storeroom adjacent to the main library" and that several hundred dollars worth of Canadian Field-Naturalist (CFN) back numbers were recovered (LAC OFNC Collection, 29 October 1948). The Council agreed to thank the OPL for storing the collection (since 1917!) by donating a set of The CFN back to 1935. Although the OPL apparently offered to continue to store

the 24 shelves worth of material at no cost to the Club, Council determined that all of the natural history and geology books should be sold (LAC OFNC Collection, 22 November 1948). No one was aware, apparently, that the Club had given the library to the OPL back in 1917 and thus was obviously in no legitimate position to sell the material. Nonetheless, the library was sold to "Mr. [Bernard] Amtmann, a dealer in second hand books …" who assured the Council that OFNC members "would be given first choice before the [collection] catalogues were sent out … through his extensive mailing list" (LAC OFNC Collection, 19 January 1950). The Club's initial share of sales before Amtmann moved to Montreal with the collection was $169 (LAC OFNC Collection, 20 November 1950); the following year Amtmann offered the Club $200 for the remaining volumes of the library which he had sold off "on a poundage basis" and for which he claimed to have incurred a considerable loss. The offer was accepted (LAC OFNC Collection, 16 November 1951) … a sad ending to what must have been a magnificent collection with an intriguing provenance.

[9] The portrait by Franklin Brownell was commissioned in late 1911 (LAC OFNC Collection, 18 December 1911) and hung in "a suitable and prominent place" in the Ottawa Public Library in the spring of 1912 (LAC OFNC Collection, 12 March 1912). In the 1920s it was transferred to the National Museum of Canada "for safekeeping" (LAC OFNC Collection, 14 December 1926) where it hung for many years in the herbarium, its actual ownership and the "temporary" nature of its placement at The Museum eventually forgotten. When this history was discovered and brought to the attention of National Museum of Natural Sciences Assistant Director (and former OFNC Vice-President) C. G. Gruchy and Agriculture Canada staff in 1985 (personal communication), arrangements were made by The Museum for cleaning and minor restorations to be undertaken. The portrait, still technically owned by the Club and on loan to The Museum, was officially donated to The Farm on 2 June 1986 by OFNC 1986-1988 President W. G. Gummer (1915-1999) as part of the celebrations of 100 years of agricultural research in Canada (Hall 1986). The Museum and the Club had now fully honoured their commitment to the memory of James Fletcher. The portrait presently hangs, appropriately enough, in the William Saunders Building, named after the Central Experimental Farm Director who hired Fletcher as Canada's first Dominion Entomologist and Botanist.

[10] *The Ottawa Naturalist* was published quarterly for a brief period (1889/1890) as a cost-saving measure but reverted to monthly publication (at the urging of Will Harrington) because of reader preference for more frequent production. This was initiated despite the Club's request for a provincial publication assistance grant being denied. An avowed Tory, John Macoun proclaimed that "politics had intervened with the success of the application and that we would have to learn to vote properly before we could hope to succeed …" (LAC OFNC Collection, 18 March 1890). The none too subtle shot at the long serving Liberal government of Oliver Mowat was quite likely an accurate observation of the politics of that day (Gywn 1984). *The Ottawa Naturalist* did eventually receive a provincial government publication grant (of $300.00), beginning in 1897. But presumably to Macoun's chagrin, this occurred with the Liberals still in power! Provincial financial assistance was received thereafter until 1924 (LAC OFNC Collection, 3 November 1924), as was generous federal publication support funding for *The Canadian Field-Naturalist* in the 1980s and 1990s.

[11] The Macoun Autobiography was reprinted as an OFNC Special Publication in the Club's centennial year (Macoun 1979), with an new introduction by Richard Glover and with both editorial notes and a biographical sketch by historian William A. Waiser.

[12] P. B. Symes presented his "nearly complete set" of *The Canadian Field-Naturalist* and its predecessors to the Club in 1923. It formed the basis for "the Club's set of original issues" (Patch 1923) which is maintained for the purposes of the current CFN editor. The set is now complete (Francis Cook, personal communication).

[13] When Pauline Snure was elected in 1948, she was the first woman president of the OFNC, despite the conspicuous affirmative action efforts on behalf of women members by James Fletcher and associates in the 1880s and again in the first decade of the 20th century.

[14] It was presumably this 75th anniversary that inspired Herb Groh to develop a biographical clipping file on OFNC Presidents and other officers. The file was presented to the Club in the early 1980s by Pierre Taschereau on behalf of Groh's widow and is now preserved in the LAC OFNC Collection.

[15] The present editor has suggested (personal communication) that this treatment might be overly critical of Senn's editorial tardiness in comparison to the at-times substantial delay of issues of the CFN during his (Cook's) tenure. While recent delays sometimes approached (though never matched) those of the 1950s, the critical difference between the two was the impact on the Club in their respective eras. The substantial publication delay in the early 1950s all but shut down Club productivity. While not to suggest that contemporary publications delays are without impact, they are clearly less threatening than those of 50 years ago.

APPENDIX 1: Ottawa Field-Naturalists' Club officers (1879-2004)

(derived from (LAC OFNC Collection Minute Books (1879-1970) and *The Canadian Field-Naturalist* listings and contemporary OFNC Council Minutes)

	President	Vice-President(s)[1]	Treasurer	Secretary(ies)[2]
1879/1880	W. White	J. Fletcher W. P. Riddell* W. D. LeSueur*	R. B. Whyte[2]	R. B. Whyte[2]
1880/1881	J. Fletcher W. R. Riddell*	R. B. Whyte W. D. LeSueur	W. H. Harrington[2]	W. H. Harrington[2]
1881/1882	J. Fletcher	R. B. Whyte H. B. Small Jr.	W. H. Harrington[2]	W. H. Harrington[2]
1882/1883	J. Fletcher	R. B. Whyte J. F. Whiteaves	W. P. Anderson	W. H. Harrington
1883/1884	H. B. Small Jr.	R. B. Whyte F. R. Latchford	W. P. Anderson	W. H. Harrington
1884/1885	H. B. Small Jr.	R. B. Whyte J. Fletcher	W. P. Anderson	W. H. Harrington
1885/1886	W. H. Harrington	John Macoun S. Woods	T. S. MacLaughlin	W. P. Anderson
1886/1887	John Macoun	R. B. Whyte S. Woods	T. S. MacLaughlin	W. H. Harrington
1887/1888	R. B. Whyte	John Macoun S. Woods*	J. Fletcher	W. H. Harrington
1888/1889	R. B. Whyte	C. F. Marsan R. W. Ells	J. Fletcher	T. S. MacLaughlin
1889/1890	R. W. Ells	H. M. Ami J. Ballantyne	J. Fletcher	T. S. MacLaughlin
1890/1891	R. W. Ells	R. B. Whyte J. Ballantyne	J. Fletcher	T. S. MacLaughlin
1891/1892	R. W. Ells	H. M. Ami T. S. MacLaughlin	G. Harmer	W. H. Harrington
1892/1893	G. W. Dawson	W. H. Harrington* M. A. Mills* F. Shutt	A. G. Kingston	H. M. Ami
1893/1894	G. W. Dawson	R. W. Ells F. Shutt	A. G. Kingston	H. M. Ami
1894/1895	G. W. Dawson	J. Fletcher F. Shutt	J. Fletcher* D. B. Dowling	H. M. Ami
1895/1896	F. Shutt	H. M. Ami A. G. Kingston	D. B. Dowling	A. Halkett
1896/1897	F. Shutt	H. M. Ami W. H. Harrington	H. M. Ami W. H. Harrington	A. Halkett
1897/1898	E. E. Prince	H. M. Ami W. H. Harrington	J. Craig*	A. Halkett
1898/1899	E. E. Prince	H. M. Ami John Macoun	J. Fletcher	W. J. Wilson
1899/1900	H. M. Ami	A. G. Kingston John Macoun	J. Fletcher	W. J. Wilson
1900/1901	H. M. Ami	W. S. O'Dell R. Bell	J. Fletcher	W. J. Wilson
1901/1902	R. Bell	D. A. Campbell W. T. Macoun	J. Fletcher	W. J. Wilson*
1902/1903	R. Bell	A. E. Attwood W. T. Macoun	A. Gibson	W. J. Wilson
1903/1904	W. T. Macoun	A. E. Attwood* A. Halkett	A. Gibson	W. J. Wilson*
1904/1905	W. T. Macoun	W. J. Wilson S. B. Sinclair	A. Gibson	T. E. Clarke
1905/1906	S. B. Sinclair	W. J. Wilson F. Shutt	A. Gibson	T. E. Clarke
1906/1907	W. J. Wilson	F. Shutt	A. Gibson	T. E. Clarke

	President	Vice-President(s)[1]	Treasurer	Secretary(ies)[2]
		A. E. Attwood		
1907/1908	W. J. Wilson	A. E. Attwood A. Halkett	A. Gibson	T. E. Clarke
1908/1909	A. E. Attwood	A. Halkett E. F. G. Eifrig	A. Gibson	T. E. Clarke
1909/1910	A. E. Attwood	A. Halkett E. F. G. Eifrig	A. Gibson	T. E. Clarke
1910/1911	A. Halkett* A. G. Kingston*	A. G. Kingston L. H. Newman	H. Groh	J. J. Carter
1911/1912	A. McNeill	A. Gibson L. H. Newman	W. T. Macoun	D. E. Blackader
1912/1913	L. H. Newman	A. Gibson J. W. Gibson	W. T. Macoun	D. E. Blackader
1913/1914	L. H. Newman	A. Gibson H. I. Smith	W. T. Macoun	E. D. Eddy
1914/1915	A. Gibson	C. G. Hewitt H. I. Smith		J. F. Watson E. D. Eddy
1915/1916	A. Gibson	C. G. Hewitt H. I. Smith	G. LaLacheur	A. Halkett* G. O. McMillan
1916/1917	H. I. Smith	C. G. Hewitt E. D. Eddy	G. LaLacheur	L. D. Burling
1917/1918	H. I. Smith	M. Y. Williams C. G. Hewitt	J. R. Dymond	L. D. Burling
1918/1919	C. G. Hewitt	L. D. Burling M. Y. Williams	J. R. Dymond*	C. L. Patch
1919[3]	M. Y. Williams	L. D. Burling P. A. Taverner	F. W. Waugh	C. L. Patch
1920	M. Y. Williams	L. D. Burling R. M. Anderson	E. B. Crampe*	C. L. Patch
1921	R. M. Anderson	G. A. Miller H. Lloyd	C. B. Hutchings	C. L. Patch
1922	R. M. Anderson	H. Lloyd G. A. Miller	C. B. Hutchings	C. L. Patch
1923	H. Lloyd	G. A. Miller N. Criddle	C. B. Hutchings	C. L. Patch
1924	H. Lloyd	G. A. Miller N. Criddle	B. A. Fauvel	J. F. Wright
1925	H. Lloyd* G. A. Miller*	G. A. Miller* N. Criddle E. M. Kindle*	B. A. Fauvel	J. F. Wright
1926	N. Criddle	E. M. Kindle C. L. Patch	B. A. Fauvel	J. F. Wright
1927	N. Criddle	E. M. Kindle C. L. Patch	B. A. Fauvel	J. F. Wright
1928	E. M. Kindle	C. L. Patch H. F. Lewis	B. A. Fauvel	J. F. Wright
1929	E. F. G. White	H. F. Lewis C. M. Sternberg* C. L. Patch*	W. Lloyd	B. A. Fauvel
1930	H. F. Lewis	M. E. Wilson C. M. Sternberg	W. Lloyd	B. A. Fauvel
1931	H. F. Lewis	M. E. Wilson C. M. Sternberg	W. Lloyd	G. S. Postethwaite
1932	C. M. Sternberg	M. E. Wilson H. Groh	W. Lloyd	G. S. Lewis
1933	C. M. Sternberg	M. E. Wilson H. Groh	W. Lloyd	G. S. Lewis
1934	M. E. Wilson	H. Groh P. A. Taverner	W. Lloyd	G. S. Lewis
1935	M. E. Wilson	H. Groh P. A. Taverner	W. Lloyd	P. Whitehurst
1936	H. Groh	P. A. Taverner R. DeLury	W. Lloyd	P. Whitehurst

	President	Vice-President(s)[1]	Treasurer	Secretary(ies)[2]
1937	H. Groh	P. A. Taverner R. DeLury	W. Lloyd	P. Whitehurst* C. W. Lounsbury*
1938	P. A. Taverner	R. DeLury* H. G. Crawford* A. E. Porsild	W. Lloyd	C. W. Lounsbury
1939	A. E. Porsild	H. G. Crawford D. Leechman	W. Lloyd	C. W. Lounsbury
1940	A. E. Porsild	H. G. Crawford D. Leechman	W. Lloyd	C. W. Lounsbury
1941	H. G. Crawford	D. Leechman F. E. Banim	W. Lloyd	C. W. Lounsbury
1942	H. G. Crawford	D. Leechman F. E. Banim	C. H. D. Clarke	J. W. Groves
1943	D. Leechman	F. E. Banim W. H. Lanceley	I. Conners	J. W. Groves
1944	D. Leechman	F. E. Banim W. H. Lanceley	I. Conners	J. W. Groves
1945	F. E. Banim	W. H. Lanceley A. L. Rand	I. Conners	J. W. Groves
1946	F. E. Banim	W. H. Lanceley A. L. Rand	I. Conners	O. H. Hewitt
1947	W. H. Lanceley	A. L. Rand P. Snure	C. Frankton	O. H. Hewitt
1948	W. H. Lanceley	P. Snure J. W. Groves	C. Frankton	H. J. Scoggan
1949	P. Snure	J. W. Groves R. Frith	C. Frankton	H. J. Scoggan
1950	P. Snure	J. W. Groves R. Frith	C. Frankton	H. J. Scoggan
1951	J. W. Groves	R. Frith W. K. W. Baldwin	R. J. Moore	H. J. Scoggan
1952	J. W. Groves	R. Frith W. K. W. Baldwin	R. J. Moore	H. J. Scoggan
1953	R. Frith	W. K. W. Baldwin H. Senn	R. J. Moore	H. J. Scoggan
1954	R. Frith	W. K. W. Baldwin A. E. Bourguignon	R. J. Moore	H. J. Scoggan
1955	W. K. W. Baldwin	L.S. Russell E. L. Bousfield	R. J. Moore	H. J. Scoggan
1956	W. K. W. Baldwin	L. S. Russell E. L. Bousfield	R. J. Moore	H. J. Scoggan
1957	L. S. Russell	E. L. Bousfield J. S. Bleakney	R. J. Moore	H. J. Scoggan
1958	L. S. Russell	E. L. Bousfield J. S. Bleakney	R. J. Moore	A. M. Banfield
1959	E. L. Bousfield	W. W. Mair D. R. Beckett	J. M. Gillett	A. M. Banfield
1960	E. L. Bousfield	W. W. Mair D. R. Beckett	J. M. Gillett	A. M. Banfield
1961	W. W. Mair* D. R. Beckett*	D. R. Beckett* V. Solman* E. Bousfield	J. M. Gillett	A. M. Banfield
1962	D. R. Beckett	W. W. Mair D. A. Smith	A. Banning	A. M. Banfield
1963	D. R. Beckett	W. W. Mair G. McGee	A. Banning	D. A. Smith
1964	G. McGee	W. W. Mair G. R. Hanes	A. Banning	A. W. Rathwell
1965	G. McGee	W. W. Mair F. R. Cook	A. Banning	A. W. Rathwell
1966	G. McGee	F. R. Cook H. Mackenzie	R. D. Wainwright	A. W. Rathwell
1967	H. Mackenzie	J. C. Woolley T. Mosquin	L. G. Howden	A. W. Rathwell

	President	Vice-President(s)[1]	Treasurer	Secretary(ies)[2]
1968	H. Mackenzie	T. Mosquin* J. Tener* G. McGee*	L. G. Howden	A. W. Rathwell
1969	H. Mackenzie	T. Mosquin W. A. Holland	F. M. Brigham	A. W. Rathwell
1970	T. Mosquin	W. A. Holland S. Thomson	F. M. Brigham	A. W. Rathwell
1971	T. Mosquin	S. Thomson I. M. Brodo	F. M. Brigham	A. W. Rathwell
1972	S. Thomson	I. M. Brodo E. C. D. Todd	P. Kevin	A. W. Rathwell
1973	I. M. Brodo	E. C. D. Todd	C. Gruchy	A. J. Erskine (RS) A. H. Reddoch (CS)
1974	I. M. Brodo	E. C. D. Todd	C. Gruchy	A. J. Erskine (RS) J. D. Lafontaine (CS)
1975	E. C. D. Todd	R. A. Foxall	P. J. Sims	A. J. Erskine (RS) C. Gruchy (CS)
1976	E. C. D. Todd	R. A. Foxall	P. J. Sims	P. J. Narraway (CS) A. J. Erskine (RS)
1977	R. A. Foxall	R. Taylor	B. Henson	D. Laubitz (RS) S. Armstrong (CS)
1978	R. A. Foxall	R. Taylor	B. Henson	D. Laubitz (RS) S. Armstrong (CS)
1979	R. Taylor	C. Gilliatt	B. Henson	D. Laubitz (RS) V. Hume (CS)
1980	R. Taylor	H. L. Dickson	B. Henson	D. F. Brunton (RS) E. F. Pope (CS)
1981	R. Taylor	H. L. Dickson* D. F. Brunton*	B. Henson	E. F. Pope (RS) W. Gummer (CS)
1982	D. F. Brunton	C. G. Gruchy P. M. Catling	P. D. M. Ward	E. F. Pope (RS) W. Gummer (CS)
1983	D. F. Brunton	C. G. Gruchy* E. F. Pope* P. M. Catling	P. D. M. Ward	E. F. Pope (RS) W. Gummer (CS)
1984	E. F. Pope	W. Gummer W. P. Arthurs	P. D. M. Ward	G. Hamre (RS)* A. Martell (CS)* B. Martin (RS & CS)*
1985	E. F. Pope	W. Gummer W. P. Arthurs*	P. D. M. Ward	A. Martell (CS)* B. A. Campbell (CS)*
1986	W. Gummer	B. A. Campbell J. Harrison	P. D. M. Ward	B. J. Martin (CS) E. Bottomley (RS)
1987	W. Gummer	D. F. Brunton J. Harrison	F. Valentine	B. A. Campbell (CS) M. Coleman (RS)
1988	J. Harrison	D. F. Brunton* K. Strang* J. Harrison	F. Valentine*	D. F. Brunton (RS)* R. John (RS)* B. A. Campbell (CS)
1989	J. Harrison	R. John K. Strang	J. Gehr	D. Duchesne (RS) M. Aksim (CS)
1990	J. Harrison	R. John D. Cuddy	M. Scromeda	E. Fox (RS) E. Evans (CS)
1991	R. John*	E. Fox* S. Blight*	G. Marston	E. Evans (CS) D. Furlong (RS)* C. Firth (RS)* N. Stow (RS)* E. Fox (RS)*
1992	E. F. Pope	vacant	G. Marston	E. Evans (CS) C. Clark (RS)
1993	E. F. Pope	M. Murphy	G. Marston	S. Gawn (RS) E. Evans (CS)
1994	E. F. Pope	M. Murphy D. Moore	G. Marston	S. Gawn (RS) E. Evans (CS)
1995	E. F. Pope	M. Murphy D. Moore	G. Marston	D. Smythe (RS) E. Evans (CS)

	President	Vice-President(s)[1]	Treasurer	Secretary(ies)[2]
1996	D. Moore	M. Murphy	G. Marston	D. Smythe (RS) E. Evans (CS)
1997	D. Moore	M. Murphy T. Reeve*	S. Shaw*	D. Smythe (RS) L. Cairnie (CS)
1998	D. Moore	E. Zurbrigg D. Smythe	S. Shaw	G. McNulty (RS) vacant (CS)[4]
1999	D. Moore	E. Zurbrigg D. Smythe	E. F. Pope*	G. McNulty (RS) vacant (CS)[4]
2000	E. Zurbrigg	R. John	E. F. Pope	J. Martens
2001	E. Zurbrigg	R. John	E. F. Pope	K. Allison
2002	E. Zurbrigg	R. John	E. F. Pope	K. Allison
2003	G. McNulty	M. R. Murphy G. Marston	E. F. Pope	S. L. Bourque
2004	M. R. Murphy	G. Marston	E. F. Pope	S. L. Bourque

* served only a portion of this term; RS – Recording Secretary CS – Corresponding Secretary

[1] First and Second Vice-President positions existed in most but not all terms.
[2] Secretary and Treasurer positions were combined until 1882;
[3] The OFNC "year" was rearranged in 1919 to coincide with the calendar year rather than the fiscal year, resulting in a 1918-1919 year ending in March 1919, a 9 month "year" for the remainder of 1919, and normal calendar years thereafter.
[4] Corresponding Secretary position left vacant for two years then eliminated; Recording Secretary position continues.

Continuing Environmental Change – An Example from Nova Scotia

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Information from personal experience, from community elders and published literature served as a basis for evaluating environmental changes in the District of North Queens and adjacent areas of Southwestern Nova Scotia over the past century. Major events included disappearance of the Caribou (*Rangifer tarandus*), the arrival of White-tailed Deer (*Odocoileus virginianus*), the severe reduction of Canada Yew (*Taxus canadensis*), disappearance of Lynx (*Lynx canadensis*), a major dieoff of Striped Skunks (*Mephitis mephitis*), decline of American Beech (*Fagus grandifolia*), the loss of mature birch (*Betula* spp.), the severe reduction of Moose (*Alces alces*), the arrival of the American Dog Tick (*Dermacentor variabilis*) and Coyotes (*Canis latrans*), and the restoration of Beaver (*Castor canadensis*). The proximate cause of many of those changes were plant and animal disease, while the ultimate causes were naturally occurring animal range expansion and human impacts. The warming of the climate over the past 150 years probably played a role. The nature and timing of the events could not have been predicted.

Key Words: Nova Scotia, plant and animal diseases, change in biota, climate change, adaptive management.

Here, I present and discuss an example of long-term environmental change. It is a narrative account of changes in the occurrence of some mammals and plants in my home area, the District of North Queens, and surrounding portions of the interior of southwestern Nova Scotia. I personally observed these changes or heard about them from my father and other community elders and further document them by reference to the available literature. I discuss the changes in the light of current resource management philosophy. Since my father was born in 1882 and was a teenager in the 1890s, the changes noted cover a century.

The District of North Queens lies in the interior of the southwestern peninsula of Nova Scotia and is centred at approximately 65°09'W and 44°18'N. It is an area of scattered farms and homesteads where the population has subsisted for 200 years on a mix of agriculture and forestry. The district contains the western portion of a swarm of glacially-formed drumlin hills that occur in Lunenburg and Queens counties (Roland 1982). Drumlins provide arable land but comprise a small proportion of the land area. Most of the district is rocky, forested terrain that, even where cultivatable and productive, was difficult for early settlers to clear. The remainder of the interior of western Nova Scotia is a complex of water bodies, bogs, fens, barrens and stony soils supporting Acadian forests of mixed conifers and deciduous tree species (Rowe 1972). When my father was born the area contained considerably more crop agriculture and improved pasture than today. For the County of Queens as a whole, approximately 30 000 acres (12 140 ha) were under agriculture in 1870 (Canada 1871). This area dropped to 7410 acres (2999 ha) by 1966 (Nova Scotia 1966). However, those were small proportions of the total area, 4.4% in 1870 and 1.1% in 1966. Because the terrain is very complex, and the forest composed of many small stands, with the whole divided into small private land parcels, timber harvest has consisted of cutting small patches or individual trees as a market or need for the wood occurred. However, in recent years there have been larger clearcuts and some conversion of mixed forest to conifer plantations on industrial ownerships. The decline in the area of mixedwood has been counterbalanced to an unknown extent by reversion of agricultural land to mixedwood forest and by improved fire protection (Telfer 1971).

Mammals

In the 1880s Caribou *Rangifer tarandus,* were still common in unsettled parts of Nova Scotia (Rand 1933; Sheldon 1936). An old hunter (the late F. M. Forrest, personal communication) told me of a trip he made when he was 16 years old (that would have been in 1888) to find Caribou. Somewhere at the west side of the present day Kejimkujik National Park he found a herd on a large barren and had a good chance to observe them and to shoot a fat yearling to replenish his provisions. Within 20 years Caribou appear to have been gone from North Queens. Another old woodsman (the late E. B. Smith, Sr., personal communication) told me that when he began to guide sportsmen in the early 1900s there were still broad trails beaten though the woods in all directions in the remote parts of the District that had been made and kept open by Caribou. Sheldon (1936) also commented on the Caribou trails. By my time the Caribou were long gone and their trails had faded away before the encroaching forest. Caribou suffered from logging and burning on their winter ranges and from poorly controlled hunting. However, the probable final cause of Caribou extirpation was

meningeal worm, *Parelaphostrongylus tenuis*, introduced by White-tailed Deer, *Odocoileus virginianus* (Benson and Dodds 1977).

The loss of a large mammal like Caribou from the regional fauna quite probably had at least minor impacts on other plants and animals living in the area. I have not been able to find any records of any observations of such impacts. However, Caribou move fast and far and feed while moving so they spread their use of vegetation out in time and space (Miller 1982). The relatively small population of Caribou in Nova Scotia would have had slight impact on other species.

Moose, *Alces alces,* were distributed throughout Nova Scotia and were the common game animal in my father's youth. However, after 1926 they were observed to be dying (Sheldon 1936; Benson 1958). The sick Moose exhibited symptoms similar to those later described by Anderson (1965) as resulting from infestation by the meningeal worm (*Parelaphostrongylus tenuis*). This organism was later found in Nova Scotia Moose by Smith et. al (1964). *Parelaphostrongylus tenuis* is relatively common in White-tailed Deer. It does little harm to whitetails but may cause heavy mortality among other species of the deer family (Thomas and Dodds 1988). By the 1940s, Moose were dying in large numbers from the condition which had come to be called "Moose Sickness" (Benson and Dodds 1977). The animals showed evidence of paralysis, blindness and other neurological symptoms although they were often in good physical condition otherwise. Annual reports of the Nova Scotia Department of Lands and Forests commented on the dead Moose. The 1949 report was typical, "Nearly all Rangers report moose as being in a healthier condition which is perhaps indicated by the decrease in the number of moose which were found dead. This number was 75, a decrease of 74 from last year" (Nova Scotia 1949: 65). Of course only a fraction of the dead Moose would have come to the attention of the authorities. Moose almost vanished from southwestern Nova Scotia by the 1960s but recovered slightly following later declines in deer numbers.

Although *P. tenuis* was found in some Nova Scotia Moose in the 1960s and has been shown to cause a "moose sickness" type of illness, that does not prove that all the animals that perished in the dieoff of Nova Scotia Moose in the 1930s and 1940s died of meningeal worm infection. However, the similarity of the symptoms displayed by the sick Moose suggests that most died of the same cause. Moose have been found to suffer from neurological symptoms where no *P. tenuis* has been observed in autopsies (Tony Nette, personal communication). Those symptoms have been recently linked to deficiencies of cobalt and vitamin B_{12} (Frank et al. 2004). However, it seems unlikely that a nutritional deficiency would cause a catastrophic dieoff like that reported in Moose in Nova Scotia in the 1940s, and the coincidence of the dieoff with the post-introduction boom in White-tailed Deer numbers suggests that *P. tenuis* was the principal cause.

My father was an adult before deer showed up in North Queens. They had been spreading across Nova Scotia with the help of some introductions, and by the late 1800s their numbers were increasing (Rand 1933). There were many reasons for the increase. Possibly the most decisive was the climatic warming that set in about 1850 (Hawboldt 1952; Lamb 1982). The first deer hunting season in Nova Scotia was in 1916 and by the 1930s deer were common (Sheldon 1936; Benson and Dodds 1977). Over 40 000 were reported killed in Nova Scotia in one year in the early 1950s – more than two for every square mile in the province (Benson and Dodds 1977). Deer remained numerous until the unusually severe winter of 1955-1956 caused a major dieoff of deer in western Nova Scotia. Since then they have fluctuated with winter conditions.

Beavers, *Castor canadensis,* were not mentioned by my father as a species that he encountered in North Queens as a young man in the 1890s and the early 1900s. The animals had been trapped almost to extirpation in Nova Scotia during the preceding century. However, in 1907 Beavers were given complete protection (Wood 1973) and the Department of Lands and Forests staff began live-trapping and transplanting them from the few remaining populations to unoccupied parts of the province.

One cold autumn dusk when I was about five years old my father took me on a short walk to a small lake where Beavers had been released. We saw a new dam blocking the outlet stream and a new house with fresh mud on it. The Beavers had made themselves at home. They soon became abundant in North Queens and remained so until after 1945. Limited trapping was allowed after that time, reducing Beaver numbers and the dense population of animals had reduced their food supply along streams and lakes. However, Beavers have continued to occur in substantial numbers in North Queens (Wood 1973).

Hunting with hounds was a favourite activity of my father and his friends. They hunted Red Foxes (*Vulpes vulpes*) and what they referred to as "wildcats". Most of the cats were Bobcats (*Lynx rufus*) but my father also described killing cats that were over six feet long from rear toes to front toes when held up by their hind legs. Those large, rangy animals were probably Lynx. More (1873) stated that there were "lucifees" (Loup cervier, Lynx) and "little lucifees" in Queens County. However, the Lynx had become rare or extirpated by the 1930s (Rand 1933; Sheldon 1936) and is now absent from the region (McCord and Cardoza 1982).

According to local tradition, there were no Striped Skunks, *Mephitis mephitis,* in North Queens when the area was first settled. The species is not mentioned by More (1873) who, as a land surveyor, was very familiar with the mammals of the region. It was said that

sometime in the mid-1800s someone brought a dead, frozen animal to a local blacksmith shop. None of the farmers who happened to be there could identify it. However, a few days later someone passed who had worked in the United States and who identified it as a skunk. By my father's time skunks were common. However, by the 1930s, skunks were gone, probably due to an epidemic of distemper (Dodds 1969) but the decline in agricultural land use may also have had a negative impact on this animal of farms and forest edge. They were found in Nova Scotia only along the New Brunswick border but by the 1960s they had once again begun to spread into central areas of the province (Dodds 1969). None were present in Kejimkujik National Park in the early 1970s (Wood 1973). However, in 2001 I observed a skunk near Ten Mile Lake, in Queens County.

My father would have had difficulty in believing that the howl of the Coyote *(Canis latrans)* could ever be heard in North Queens. Yet in the 1970s Coyotes arrived in Nova Scotia. In North Queens, the population of White-tailed Deer in Kejimkujik National Park was apparently reduced by Coyotes which were commonly seen along Park roads and heard on still nights throughout the area (Patterson 1994). The impact of Coyotes not only on deer but on competing Red Foxes, on Snowshoe Hares (*Lepus americanus*), microtine rodents, grouse (*Bonasa umbellus* and *Canachites canadensis*) and other ground-nesting birds must have been considerable.

Plants

Before the arrival of White-tailed Deer, the forest floor in mature spruce-hemlock stands was carpeted with Canada Yew, *Taxus canadensis*. This evergreen shrub is highly palatable to deer and by the 1940s it had been eliminated from the forest. In the 1960s one experienced biologist (the late Harrison F. Lewis, personal communication) told me that the only surviving yew bush that he knew of was growing beside the outhouse at a warden cabin where one branch had grown through the wall of the well-ventilated facility and had thus escaped browsing.

One of the most important trees of North Queens is the White Pine (*Pinus strobus*) (Rowe 1972). White Pines were a major resource in North Queens historically (More 1873). However, in my father's time regenerating White Pine was increasingly attacked by the White Pine Weevil (*Pissodes strobi*). That insect kills the leaders on the top of the tree, creating crooked stems or, at worst, "cabbage trees" whose lower branches continually grow up to take the place of the weevil-killed central stem. White Pine Weevil is a native North American insect. However, the first official records of its presence in the Maritimes date from about 1920 (Martineau 1984). The insect quickly spread throughout the range of the White Pine including North Queens. The spread of the weevil was facilitated by the extensive areas of regenerating forest created by logging, fire and the invasion of old fields by White Pine (Belyea and Sullivan 1956). By my time the value of the White Pine resource in North Queens was greatly reduced and crooked, multi-stemmed pine occupied much space in the forest. White Pine remains an important tree in the district but the weevil attacks have reduced the value of many stems for lumber.

The American Beech, *Fagus grandifolia,* was common in North Queens when my father was a boy. Pure beech stands occupied the ridge tops and beech trees were also scattered throughout the hardwood and mixedwood stands. Beech nuts were always an important seasonal food source for wildlife. Black Bears (*Ursus americanus*), especially, sought them out for a high fat and protein food before hibernation. When whitetails arrived in Nova Scotia they quickly became the most important consumers of the dwindling supply of nuts. Loucks (1962) cited evidence that beech was formerly more common in southwestern Nova Scotia. He believed that wildfire had reduced the occurrence of the species. Early in the 1900s the Woolly Beech Scale (*Cryptococcus* spp.), an insect that spreads Beech Nectria Fungus (*Nectria coecinea* var. *faginata*), arrived in Nova Scotia, probably an accidental introduction from Europe (Boyce 1961). The fungus gains entry to the tree through holes made by the Woolly Beech Scale. Saunders (1970) stated that Woolly Beech Scale entered Nova Scoria from Europe about 1890 and that the fungus also entered North America through Nova Scotia in about 1929. Nectria disease debilitates beech by invading the bark and cambium, eventually killing the tree. Roland and Smith (1969: page 341) noted that "All the beech in N.S. is severely affected by the Nectria beech canker." Most beech in North Queens was unthrifty and dying by the mid-twentieth century and in all cases moribund stems were thoroughly infested with Nectria cankers. Beech have declined substantially (Telfer 1971). They have been replaced by species like Sugar Maple (*Acer saccharum*) and Red Maple (*Acer rubrum*), Hemlock (*Tsuga canadensis*) and Red Spruce (*Picea rubens*).

White Birch *(Betula papyrifera)* and Yellow Birch (*Betula alleghaniensis*) were prominent trees in the North Queens forest when my father was a boy. Indeed the old farmhouse in which he was born and died was sheathed with bark of the white birch between the wallboards and the shingles. In the mid-1930s a die-back was observed in the birch (Hawboldt 1952. Mature stands all died. This phenomenon occurred all over northeastern North America.

Temperatures were high in the 1930s following a steady rise from Little Ice Age conditions that existed before the 1850s (Hawboldt 1952). One hypothetical cause of birch mortality was that the warming climate altered the species composition of the mycorrhizal flora in the soil to the detriment of species that could enter into symbiotic relationships with birch roots

(Hawboldt 1952). Birch would thus have suffered from nutrient deficiencies. Although birch regeneration survived, live mature trees were very scarce by my time. One would have had to travel a long way to collect enough bark to sheath a house. In the 1960s I worked on forest inventories in a remote part of the District where the mature forest had formerly been dominated by a mixture of birches, Red Spruce and Hemlock (Fernow 1912), but by then the birches were rotten snags and Red Spruce, White Pine, Balsam Fir (*Abies balsamifera*) and Red Maple were sprouting in the gaps created by their death.

Arachnids

An invading organism that caused excitement in North Queens in the mid-twentieth century was the American Dog Tick (*Dermacentor variabilis*). Opinion is divided on whether the ticks were relict in a small area in Western Nova Scotia or if they were introduced. One woodsman told me of encountering ticks along a small section of the Tusket River, near the western end of Nova Scotia, during a canoe trip early in the 1900s (the late F. M. Forrest, personal communication). The distribution pattern shown by Dodds et al. (1969) suggests dispersion from an epicentre of infection. The Tusket River flows through the area of earliest distribution. By the 1930s loggers working in the western part of North Queens began to complain of tick bites. Ticks advanced on a broad front across the district in the late 1940s and the 1950s, causing consternation among the people who were unused to them. Since the 1960s, American Dog Ticks have continued to spread eastward in Nova Scotia (Andrew Hebda, personal communication).

Weather

Nova Scotia is on the track of the equatorial Atlantic hurricanes. North Queens has been occasionally lashed by at least the fringes of those storms. In 1939, the area was hit by a hurricane that blew down many trees but did limited damage in closed stands. However, in 1954, a powerful hurricane, code named "Edna", struck North Queens (Hawboldt and Bulmer 1958). Mature and old forests suffered particularly. Hurricane Edna was followed by a campaign of salvage logging as landowners tried to recover as much of the blowdown as possible. The forest openings were invaded by regeneration of Red Spruce, Red Maple, White Pine and particularly by Balsam Fir in place of the dominant Hemlock of the former stands.

Prediction and Management

Causes of some of the observed changes were natural, like birch dieback and distemper, while others were due at least in part to human intervention. There were some introductions of White-tailed Deer to Nova Scotia that probably accelerated their spread. Logging, small farming and attendant wildfires no doubt increased the amount of suitable habitat for deer and also the area occupied by White Pine regeneration, the habitat of the White Pine Weevil. Hunting probably hastened the extirpation of Caribou and Lynx and the near extirpation of beaver. Coyotes may have been able to invade eastern North America partly because European settlers extirpated Grey Wolves, *Canis lupus*, from regions to the west of Nova Scotia. Ticks and the insect vector and the fungus involved in the beech *Nectria* disease may have been accidentally introduced. Climatic warming over the past 150 years interacted in a complex way with other causes of ecological change.

The most important factors causing change to the terrestrial biota in North Queens operated haphazardly. Most were outbreaks of plant and animal diseases and parasites. Unpredictable outbreaks of disease are sometimes not considered to be very important by renewable resource managers simply because they are random and basically unforeseeable. Also, the education of resource managers usually focuses on other topics. However, Hurricane Edna represented another kind of random event. There was sufficient evidence of the occasional occurrence of such severe hurricanes that shrewd ecosystem managers would probably have allowed for their possible occurrence when preparing management plans.

The observed ecological changes in North Queens did not damage basic ecological functions like production, herbivory and predation. However, the suite of species involved changed. White-tailed Deer to some extent replaced Moose and Caribou as consumers while Coyotes became important predators as Lynx had been previously. After decades of absence, Beavers were brought back in numbers by deliberate management. Energy flow through the ecosystem was unimpaired but flowed through somewhat different channels. The observed changes exemplify the fluidity and unpredictability of nature (Botkin 1990).

What might have happened if, beginning in the 1890s, the forests and wildlife of North Queens had been under a modern regime of ecosystem management? Foresters might have made management plans aiming at production of a steady supply of birch logs. All would have been well for the first fifty years, then they would have found that the birch growing stock was dying and that spruce and fir were taking its place. As time went on the beech would also have been lost as a commercial species. Forest management would have had to be altered, as it indeed was following Hurricane Edna when managers were forced to revise their thinking about harvesting techniques (Johnson 1986) and deal with storm-caused openings and changes in forest composition. Conversely, the patchy nature of the storm-damaged forests provided improved habitat for White-tailed Deer and Moose.

Wildlife managers would have found a major ungulate species, the Caribou, suddenly declining. Even if the meningeal worm problem had been known, would

managers have tried solve it by exterminating the White-tailed Deer population? Whitetails were by then spread thinly over the entire province. By the time Moose also declined there were so many deer that eradication would have been impossible. Even without parasites, how would biodiversity managers have viewed the invasion of exotic whitetails especially since they were also the culprits in the extirpation of the Canada Yew? Managers would have been largely helpless to protect the yew except possibly by fencing small reserved patches. Although "ecosystem" preservation is often a suitable management approach to maintain threatened species, it would have been counterproductive in this case because old hemlock/spruce forest is preferred winter habitat for whitetails as well as the site of best yew growth (Schierbeck 1931). Lynx still remain on Cape Breton Island so protection from hunting might have been adequate to recover the species on the mainland of Nova Scotia as it did for the Beaver. Because skunks appear to have died from distemper, reintroduction of healthy animals following the dieoff might also have re-established viable populations and prevented local extirpation.

Our hypothetical ecosystem managers would have emerged from the hundred-year period somewhat battered. They would have lost a member of the charismatic megafauna, the Caribou. They would no doubt have been chagrined by the fact that the district had been overrun by the exotic White-tailed Deer and Coyotes, not to mention the obnoxious dog ticks. Some major tree species would also have been drastically reduced. However, a major understorey shrub and two mammal species might have been rescued and one mammal species, the Beaver, was indeed returned to the area by management. Would the public consider that money spent trying to maintain the ecosystems as they were in the 1890s to have been well spent as part of a worthwhile effort to "preserve" "nature" in the region? Or would managers simply be seen as having cast themselves in front of the juggernaut of inevitable ecological change?

In the 1890s the coming changes and their impact could not have been foreseen. If managers at that time had set goals like doubling the sustainable harvest of White Birch and developing an industry to use it, or if they had set out to double the Caribou population to satisfy outfitters, they would have been in for a rough time. Yet, such factory-type production goals are often set in resource management.

This example highlights the significance of scale in biodiversity conservation. Would it have been worthwhile to try to keep species that are still common elsewhere in North America, like Caribou, Lynx, Striped Skunks, and Canada Yew, in the district or even in Nova Scotia? At what price should we try to keep everything that was present historically in a local or regional biota? Or should the waxing and waning of species' ranges be accepted as inevitable?

Although such a comprehensive management approach would have been unthinkable in the 1890s, a program of adaptive management (Walters 1986) would have been appropriate. With the adaptive model in mind, managers might have been aware of the likelihood of natural variability and therefore cautious in goal setting. They could have initiated a program of monitoring that might have picked up changes in species status in their early stages when some prediction of the magnitude of upcoming impacts could have been made. While little could have been done to change the course of events in the short term, a more comprehensive and quantitative understanding of the operation of nature might have led to effective interventions later on.

The haphazard nature of the changes in the ecology of North Queens during the past hundred years underlines the difficulty of predicting what will happen next in nature. One is reminded of the soldier's axiom regarding shellfire, "You won't hear the one that gets you". The example of North Queens demonstrates the inevitability of environmental change and emphasizes the value of a flexible approach to forest and wildlife management.

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Habitat Segregation Among Songbirds in Old-Growth Boreal Mixedwood Forest

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The foraging behaviour of ten species of insectivorous songbirds — Boreal Chickadee (*Poecille hudsonicus*), Golden-crowned Kinglet (*Regulus satrapa*), Ruby-crowned Kinglet (*R. calendula*), Blue-headed Vireo (*Vireo solitarius*), Tennessee (*Vermivora peregrina*), Blackburnian (*Dendroica fusca*), Magnolia (*D. magnolia*), Yellow-rumped [Myrtle] (*D. coronata*), Black-throated Green (*D. virens*), and Bay-breasted (*D. castanea*) warblers — was observed in the boreal mixedwood forest of Prince Albert National Park in central Saskatchewan. Birds segregated their habitat use by preferentially foraging in different tree species, and through preferential use of different foraging locations (height and position) within trees.

White Spruce (*Picea glauca*) was used more than expected by Yellow-rumped Warblers, and Golden-crowned and Ruby-crowned kinglets. Tennessee and Magnolia warblers used White Birch (*Betula papyrifera*), more than expected and Boreal Chickadees and Blue-headed Vireos used Balsam Fir (*Abies balsamea*) more than expected. Boreal Chickadees, Ruby-crowned Kinglets, and Tennessee, Blackburnian and Yellow-rumped warblers all used the bottom part of trees less than expected, while Blue-headed Vireos foraged near the top of trees less than expected. Large inner branches were avoided by Tennessee, Blackburnian and Yellow-rumped warblers, while Bay-breasted Warblers and Blue-headed Vireos avoided small outer twigs. In conifers, Blackburnian Warblers foraged significantly higher in the trees than all other species except Black-throated Green and Bay-breasted warblers. Blackburnian Warblers also foraged significantly higher than Blue-headed Vireos and Magnolia Warblers in deciduous trees.

Key Words: Songbirds, behaviour, foraging, boreal forest, old-growth, Prince Albert National Park, Saskatchewan.

Behavioural interactions and niche partitioning in songbirds have received much attention in the literature (MacArthur 1958; Sabo 1980; Maurer and Whitmore 1981). For many boreal songbirds, however, much on their basic biology remains poorly understood (Sodhi and Paszkowski 1995). Many of the detailed behavioral descriptions have come from studies conducted in the New England States (Rabenold 1978; Robinson and Holmes 1982; Hunt and Flaspohler 1998). This is likely an incomplete description for some birds, as several of the species discussed have their breeding ranges almost entirely restricted to the Canadian boreal forest (Ficken et al. 1996; Rimmer and McFarland 1998). Studies on the southern fringes of the boreal forest, in Maine or Minnesota, are not adequate on their own to understand boreal ecology as many of the plant and animal species are not the same as further north (Rowe 1972; Acton et al. 1998). Even for wide-ranging species, there is evidence that birds do not behave the same way and do not use the same kind of habitat in all parts of their range (Noon et al. 1980; Collins 1983; Robichaud and Villard 1999).

Recent studies in the boreal forest have focused on habitat associations, and habitat requirements of songbirds (Schieck et al. 1995; Kirk et al. 1996). This information is urgently needed in light of increased pressure from large-scale forestry in this region (Cummings et al. 1994). There is mounting evidence to show that mature and old boreal mixedwood forest support an entirely different suite of species not found in younger age classes (Stelfox 1995; Cumming and Diamond 2002). These older age classes of forest are currently under a harvesting intensity that is disproportionate to their abundance in the landscape (Cummings et al. 1994; Weyerhaeuser 1998*).

The goal of this project was to investigate details of within-stand habitat segregation among boreal songbirds, focusing on the foliage-gleaning songbird guild of old (>120 years) boreal mixedwood forest. This type and age of forest was chosen as it was biologically the most diverse and structurally the most heterogeneous habitat in the region (Erskine 1977; Johnson et al. 1995; Robichaud and Villard 1999). In addition, mature to old (80+ years), mixedwood forest will become increasingly rare at the landscape level if current land use practices (i.e., logging, oil and gas exploration and agriculture) continue at their present rate (Cummings et al. 1994; Hobson et al. 2002; Schneider et al. 2002*).

Study Area

This study was carried out in the boreal, mixedwood forest of Saskatchewan (Kabzems et al. 1986; Acton et al. 1998), in Prince Albert National Park (53°35'N, 106°00'W) during 1990 and 1991 (see Bayne and Hobson 1997 for description). Three sites were chosen in forest stands that were >40 ha in area and >120 years old. Sites were as similar in topography and vegetative cover as field conditions allowed. Stands were aged by forest inventory maps, and by taking core samples from six of the largest trees on each site. Each study

site was surrounded by continuous forest of similar type, but younger age. None of the study sites had been subjected to forest harvesting, and wildfire was the driving force behind forest succession in this area (Weir et al. 2000).

The study sites were structurally very heterogeneous, with many tree-fall gaps and many standing dead trees. These canopy gaps allowed for regeneration, which resulted in a wide range of tree sizes and ages. Dominant tree species were White Spruce, *Picea glauca*, Balsam Fir, *Abies balsamea*, and Trembling Aspen, *Populus tremuloides*, with scattered White Birch, *Betula papyrifera*. Average canopy height was 21 metres with a maximum height of 38 metres (Cumming 1995). White Spruce was the only species that reached heights of over 30 metres, with some specimens also having diameters in excess of one metre. Understory trees (<12 metres), were mainly Balsam Fir, while the main shrubby species were Balsam Fir, White Birch saplings, and Alder, *Alnus* sp. Shrub distribution was patchy, with dense patches occurring in tree-fall gaps, and scattered shrubs in the rest of the study area. The most abundant ground cover species were various mosses, Bunchberry (*Cornus canadensis*), Wild Sarsasparilla (*Aralia nudicaulis*), Ostrich Fern (*Matteuccia struthiopteris*) and several horse-tail species (*Equisetum* spp.).

Methods

Observations on bird behaviour took place from late May to early August in 1990 and 1991, and birds were observed between 04:00 (dawn) and 21:00 (dusk). Upon locating a focal bird, continuous observations were made using binoculars until the bird was lost from sight (Altman 1974; Martin and Batson 1986). To avoid possible biases, observations that lasted less than five seconds or longer than two minutes were not used in the analysis. Bird species, behaviour, tree species and bird position in the tree were recorded. Bird height was estimated to within three metres. Linear regression analysis (Zar 1996) was used to ensure that estimates accurately reflected clinometer-measured heights (Cumming 1995).

In addition to behavioural observation, unlimited distance point counts (Bibby et al. 1982) were conducted twice during the breeding season (June), in order to estimate relative abundances of the various bird species. The average number of individuals per point count for each bird species was obtained by taking the maximum number recorded for that species and dividing by the number of point counts. Data from the three sites were pooled and used as a relative index of abundance for the study as a whole. For more details on bird species abundances see Cumming and Diamond (2002).

Following the method of MacArthur (1958), conifers were divided into 15 zones; 5 vertical and 3 horizontal, to determine in which part of the tree birds were foraging (Figure 1). Vertical zones divided the tree into fifths, with zone 1 at the top and zone 5 at the bottom. Horizontal zones corresponded to the outer part of the branch with new growth, fresh needles and small twigs (zone T), the middle layer of older needles and larger branches (zone M), and the inner part of the branch, largely devoid of needles with large diameter branches (zone B). A similar system was used for deciduous trees except they were divided into three vertical zones due to their more globular shape (Figure 2).

Although many birds exhibit male-female foraging differences (Holmes 1986), data for both sexes were pooled since the focus of the study was on interspecific differences in habitat use and because some species in the study were not sexually dimorphic. Bird foraging behaviour (tree zone use), did not differ significantly between the two species of conifer or between the two species of deciduous trees. Therefore, data for each bird species was pooled based on either coniferous or deciduous trees (Cumming 1995).

Vegetation in the study areas was measured using a modified James and Shugart (1970) method. Ten 0.04 ha circles (22 m diameter) were established in each study area, one centered on each of five point count stations and one at 50 metres in a random direction from that point. Within each circle, species, height in meters and diameter at breast height (dbh) in cm for all trees larger than 7 cm dbh were recorded. Percent basal area for each tree species was calculated using dbh values. Basal area more accurately reflected tree availability to birds than numbers of trees, due to heterogeneity in tree size.

To check for possible visibility biases in the various tree species, simultaneous confidence intervals (Chi-squared with Bonferroni confidence intervals) were constructed by pooling the number of seconds of observation for all bird species (Byers et al. 1984). Simultaneous confidence intervals were also used to assess whether birds preferred or avoided certain tree species. Chi-squared test with Yates correction (Zar 1996) were used *post priori* to determine if birds had a preferred foraging zone within trees. Foraging diversity was analyzed using the Shannon Index (Shannon and Weaver 1949). To assess niche overlap between species, the proportion of observations each bird species spent in each of the 15 possible tree zones (9 zones in deciduous trees) was compared between each species pair using Morisita's Index of overlap (see Diamond 1983). With this index, potential niche overlap can vary from 1 (complete overlap) to 0 (no overlap). Foraging height data were analyzed using a 1-way Anova (Proc GLM; SAS Institute 1988), and the results subjected to a Tukey's HSD pair-wise comparison test (with P=0.05).

Results

Tree Species Preference

By basal area, White Spruce, Balsam Fir, Trembling Aspen and White Birch comprised 46%, 30%, 20%, and 4%, respectively, of the available arboreal habitat.

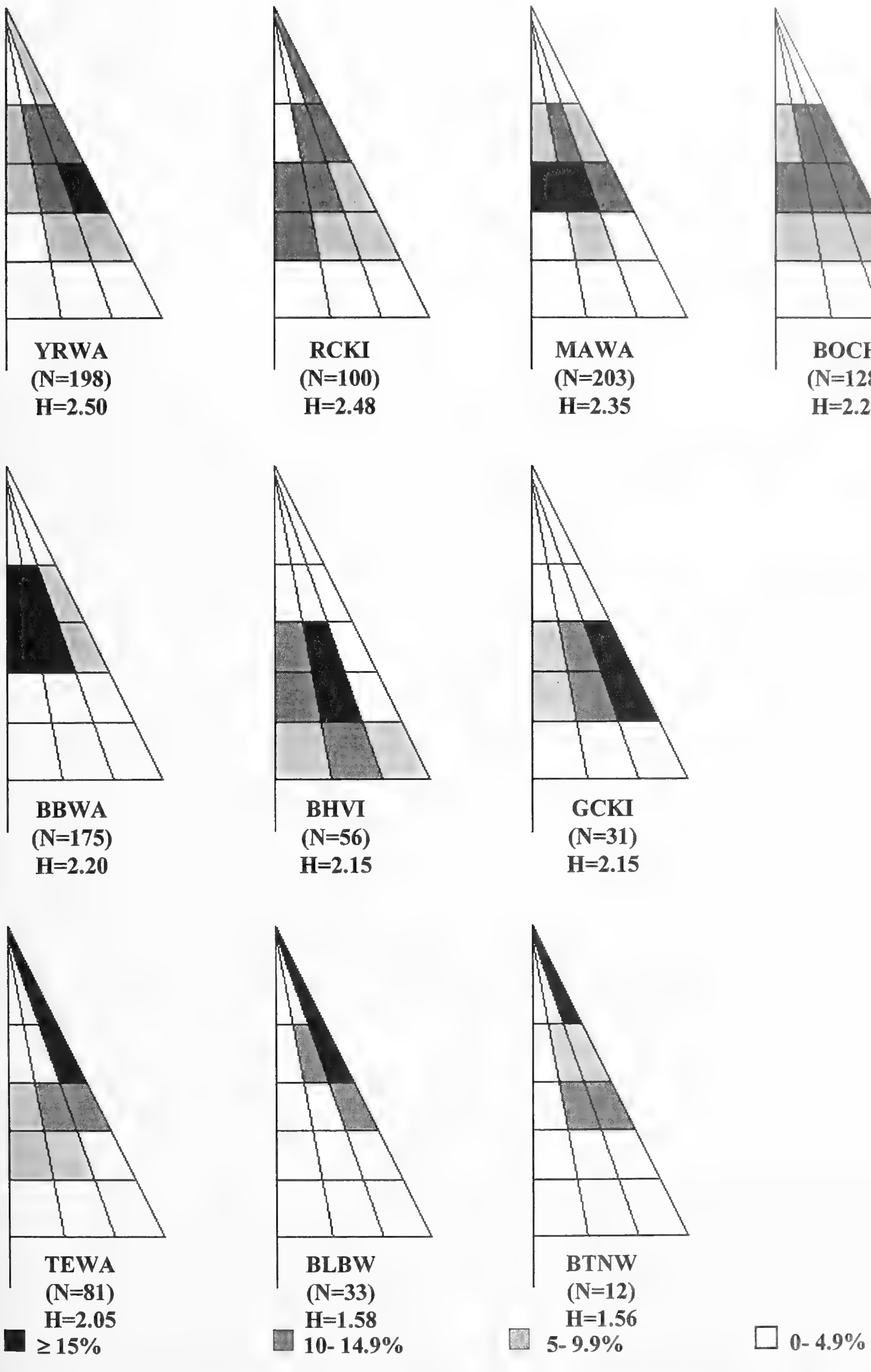

FIGURE 1. Songbird use of zones in coniferous trees. Shadings indicate frequency of observations within a zone (see legend). N= number of observations, H= Shannon diversity index. See Table 4 for species abbreviations.

White Spruce was used more than expected by Yellow-rumped (Myrtle) Warblers, (*Dendroica coronata)*, Golden-crowned (*Regulus satrapa*) and Ruby-crowned (*R. calendula*) kinglets and in proportion to its availability by all other species (Table 1). Balsam Fir was used more than expected by Boreal Chickadees (*Poecile hudsonicus*) and Blue-headed Vireos (*Vireo solitarius*) but less than expected by Tennessee Warblers (*Vermivora peregrina*). White Birch was used more than expected by Tennessee and Magnolia (*Dendroica magnolia*) warblers, while Trembling Aspen was used less than expected by Boreal Chickadees, Golden-crowned and Ruby-crowned kinglets, Blue-headed Vireos, Yellow-rumped and Magnolia warblers (Table 1). Bay-breasted Warblers (*Dendroica castanea*) used all tree species in proportion to their availability; however, they did exhibit a tendency to prefer White Spruce and avoid White Birch that was approaching significance. Blackburnian (*D. fusca*) and Black-throated Green (*D. virens*) warblers were not tested due to insufficient sample size (Brennan and Morrison 1990).

Point counts

All ten species were found in all three study sites, except Black-throated Green Warbler, which only occurred in one of the three study sites. Average bird abundance per point count from most to least abundant was; Magnolia Warbler (1.2), Yellow-rumped Warbler (0.8), Bay-breasted and Tennessee warblers (0.7), Blackburnian Warbler and Ruby-crowned Kinglet (0.4), Blue-headed Vireo (0.3), Boreal Chickadee and Golden-crowned Kinglet (0.2) and Black-throated Green Warbler (0.1).

Foraging Zones

In coniferous trees the most diversely foraging species (in order) were Yellow-rumped Warblers, Ruby-crowned Kinglets, Magnolia Warblers, and Boreal Chickadees (Figure 1). These species were observed in most tree zones and had the highest diversity indices (Shannon and Weaver 1949). The least diversely foraging species were Black-throated Green Warblers, Blackburnian Warblers and Blue-headed Vireos (Figure 1).

In the vertical zones, Ruby-crowned Kinglets, and Tennessee and Yellow-rumped warblers used the bottom of the tree, less than expected, while Boreal Chickadees and Golden-crowned Kinglets used the top and bottom less than expected (Table 2). Blackburnian and Bay-breasted warblers used the bottom two zones less than expected, while Blue-headed Vireos used the top two zones less than expected (Table 2). For the horizontal zones Bay-breasted Warblers and Blue-headed Vireos both used small twigs on the ends of branches (zone T) less than expected, while Tennessee and Blackburnian warblers used small twigs (zone T) more than expected (Table 2). Yellow-rumped Warblers use large inner branches (zone B) less than expected, while Boreal Chickadees, Golden-crowned and Ruby-crowned kinglets and Magnolia Warblers showed no significant difference in their use of inner and outer branches. Black-throated Green Warblers were not tested due to insufficient sample size (Brennan and Morrison 1990). In deciduous trees, only six of the ten species had a large enough sample size to test foraging zone use (Figure 2). In deciduous trees, Blackburnian Warblers used the top of the trees more than expected. Yellow-rumped, Magnolia and Blackburnian warblers used zone B less than expected, and Tennessee Warblers used zone T more than expected (Table 2).

Niche Overlap

In conifers, niche overlap varied from 0% between Blue-headed Vireos and Blackburnian Warblers to 95% between Yellow-rumped Warblers and both Magnolia Warblers and Boreal Chickadees The four most diversely foraging species, Boreal Chickadees, Ruby-crowned Kinglets, and Yellow-rumped and Magnolia warblers, all overlapped each other by >80%. In deciduous trees, the most foraging overlap was between Yellow-rumped and Blackburnian warblers and between Magnolia and Tennessee warblers; both species pairs overlapped by 88% (Table 3). The least amount of overlap in deciduous trees (40%), was between Black-throated Green and Bay-breasted warblers.

TABLE 1. Bird use of different tree species compared to the tree's availability (χ^2 test with Bonferroni confidence intervals, DF=3 for all species).

Bird Species	Use > Expected	Use < Expected	χ^2	P
Boreal Chickadee	Balsam Fir	Trembling Aspen	43.3	***
Golden-crowned Kinglet	White Spruce	Trembling Aspen	10.1	*
Ruby-crowned Kinglet	White Spruce	Trembling Aspen	5.9	*
Blue-headed Vireo	Balsam Fir	Trembling Aspen	6.3	*
Tennessee Warbler	White Birch	Balsam Fir	50.7	***
Magnolia Warbler	White Birch	Trembling Aspen	10.9	*
Yellow-rumped Warbler	White Spruce	Trembling Aspen	21.2	**
Bay-breasted Warbler	–	–	5.0	n.s.

Significance: *< 0.05, **<0.01, ***<0.001

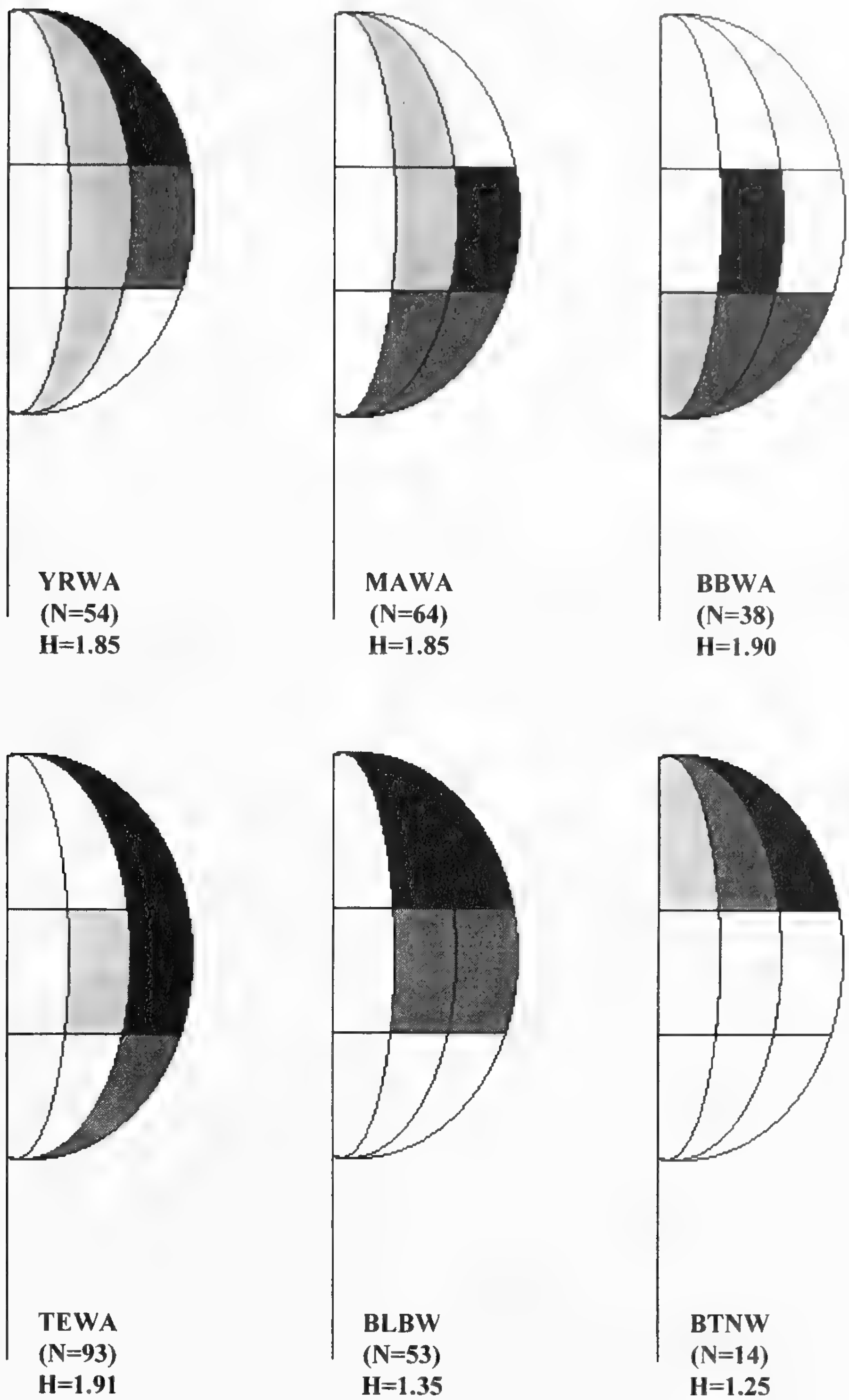

FIGURE 2. Songbird use of zones in deciduous trees. Shadings indicate frequency of observations within a zone (see legend). N= number of observations, H= Shannon diversity index. See Table 4 for species abbreviations.

Foraging Height

In coniferous trees, the average foraging height of Blackburnian Warblers was significantly higher than all other species except Black-throated Green and Bay-breasted warblers (Table 4). Black-throated Green and Bay-breasted warblers both foraged significantly higher than Magnolia Warblers and Blue-headed Vireos. Foraging heights of all other species were not significantly different (Table 4). In deciduous trees, the average foraging height of Blackburnian Warblers was significantly higher than that of Blue-headed Vireos and Magnolia Warblers but not significantly different from other species.

Canopy vs. *Subcanopy Use*

Blackburnian, Black-throated Green, and Tennessee warblers were seen in canopy level trees (>12 metres) in two-thirds or more of all observations (Table 5). At the other extreme, two-thirds of the observations on

TABLE 2. Bird use of tree zones where zone use was significantly more or less than expected (χ^2 test with Yates's correction; DF=1 for all species).

Species	Horizontal Zones				Vertical Zones			
	T, M, B	Use	χ^2	P	1 to 5	Use	χ^2	P
In Coniferous Trees								
Boreal Chickadee	n.s.				1, 5	<	20.4	***
Golden-crowned Kinglet	n.s.				1, 5	<	14.5	***
Ruby-crowned Kinglet	n.s.				5	<	16.5	***
Blue-headed Vireo	T	<	20.9	***	1, 2	<	11.1	***
Tennessee Warbler	T	>	14.9	***	5	<	11.2	***
Blackburnian Warbler	T	>	18.5	***	4, 5	<	7.4	**
Magnolia Warbler	n.s.				3	>	13.7	***
Yellow-rumped Warbler	B	<	14.6	***	5	<	10.1	**
Bay-breasted Warbler	T	<	10.5	**	4, 5	<	7.5	**
In Deciduous Trees								
Tennessee Warbler	T	>	30.3	***	n.s.			
Blackburnian Warbler	B	<	24.9	***	1	>	6.6	*
Magnolia Warbler	B	<	15.5	***	n.s.			
Yellow-rumped Warbler	B	<	23.7	***	n.s.			

Significance: *< 0.05, **<0.01, ***<0.001; T = outer part of branch with new growth, fresh needles and small twigs; M = middle layer of older needles and larger branches; B = inner part of branch, largely devoid of needles with large diameter branches; 1 to 5: vertical zones, 1 = top, 5 = bottom.

TABLE 3. Average (mean ± SD) foraging height (metres) in coniferous and deciduous trees. Species marked with * foraged significantly higher than other species (1-way Anova with Tukey's HSD test, P=0.05).

Bird Species	Coniferous	Deciduous
Boreal Chickadee	6.1 ± 3.4	9.1 ± 5.2
Golden-crowned Kinglet	7.0 ± 2.9	9.2 ±3.1
Ruby-crowned Kinglet	7.3 ± 4.7	9.5 ± 4.7
Blue-headed Vireo	6.1 ± 2.0	6.3 ± 3.8
Tennessee Warbler	8.6 ± 3.3	9.5 ±5.7
Blackburnian Warbler	15.7 ±7.8 *	15.7 ± 3.9*
Magnolia Warbler	5.8 ± 2.2	6.9 ± 5.0
Black-throated Green Warbler	12.7 ± 7.8*	11.4 ± 3.8
Yellow-rumped Warbler	7.0 ± 4.2	11.2 ± 3.8
Bay-breasted Warbler	10.3 ± 4.8*	11.8 ± 3.1

Coniferous: Blackburnian Warbler foraged significantly higher than all but Black-throated Green Warbler and Bay-breasted Warbler. Black-throated Green Warbler and Bay-breasted Warbler foraged significantly higher than Blue-headed Vireo and Magnolia Warbler.
Deciduous: Blackburnian Warbler foraged significantly higher than Blue-headed Vireo and Magnolia Warbler.

Magnolia Warblers and Boreal Chickadees were in subcanopy trees (Table 5). Blue-headed Vireos and Ruby-crowned Kinglets were approximately equal in their use of canopy and subcanopy trees, while Golden-crowned Kinglets and Yellow-rumped and Bay-breasted warblers tended to be observed slightly more often in canopy level trees (Table 5). Yellow-rumped Warblers were observed in canopy level trees significantly more than Magnolia Warblers (Z=5.2, P<0.001) and Boreal Chickadees (Z=3.4, P<0.001).

Discussion

Tree Species Preference

The four main tree species in the study area (White Spruce, Balsam Fir, Trembling Aspen, and White Birch), were not equally abundant, nor equally large (Cumming 1995). If abundance alone had been used as the criteria for tree availability for foraging then Balsam Fir would have appeared to comprise a larger proportion of available habitat than it actually did.

Patches of old, White Spruce-dominated forest are relatively rare in Saskatchewan (Kabzems et al. 1986; Acton et al. 1998); therefore, it was expected that birds which prefer White Spruce would selectively occupy this habitat. The data appear to support this, as all species in the study used White Spruce either in proportion to, or greater than, its abundance. Yellow-rumped Warblers and Golden-crowned and Ruby-crowned kinglets all used White Spruce more than expected. Boreal Chickadees and Blue-headed Vireos used White Spruce in proportion to its abundance and used Balsam Fir more than expected. All five species used Trembling Aspen less than expected (Table 1). This is similar to their behaviour elsewhere, as other researchers have found these five species to be conifer specialists (Keast and Saunders 1991; Ingold and Wallace 1994; Ingold and Galati 1997).

Trembling Aspen was the least favored tree; it was used less than expected by half the bird species in the study. Previous research has suggested differences in insect abundance may exist between aspen and other tree species (Ives and Wong 1988). Holmes and Robinson (1981) suggested structural characteristics of aspen trees and their leaves may impede foraging by insectivorous birds. However, Greenburg (1979) felt that Yellow-rumped and Bay-breasted warblers were phys-

TABLE 4. Foraging overlap between species in coniferous and deciduous trees (Morisita's Index).

Bird species	YRWA	MAWA	BBWA	TEWA	BLBW	BTNW	RCKI	BOCH	GCKI	BHVI	Average % Overlap
In coniferous trees											
YRWA	–	0.95	0.72	0.85	0.50	0.60	0.87	0.95	0.82	0.52	0.75
MAWA		–	0.82	0.71	0.32	0.50	0.84	0.86	0.85	0.61	0.72
BBWA			–	0.50	0.28	0.44	0.72	0.81	0.60	0.47	0.60
TEWA				–	0.78	0.72	0.85	0.91	0.65	0.40	0.71
BLBW					–	0.85	0.52	0.44	0.22	0	0.43
BTNW						–	0.52	0.48	0.40	0.20	0.52
RCKI							–	0.83	0.72	0.50	0.71
BOCH								–	0.63	0.46	0.71
GCKI									–	0.57	0.61
BHVI										–	0.41
In deciduous trees											
YRWA	–	0.72	0.83	0.86	0.88	0.75					0.81
MAWA		–	0.72	0.88	0.78	0.50					0.72
BBWA			–	0.60	0.66	0.40					0.64
TEWA				–	0.82	0.73					0.78
BLBW					–	0.85					0.80
BTNW						–					0.65

YRWA= Yellow-rumped Warbler, MAWA= Magnolia Warbler, BBWA= Bay-breasted Warbler, TEWA= Tennessee Warbler
BLBW= Blackburnian Warbler, BTNW= Black-throated Green Warbler, BHVI= Blue-headed Vireo
BOCH= Boreal Chickadee, RCKI= Ruby-crowned Kinglet, GCKI= Golden-crowned Kinglet,

TABLE 5. Bird use of canopy versus subcanopy trees, from most to least canopy using species.

Bird Species	Number of Observations Canopy	Subcanopy
Blackburnian Warbler	62	7
Black-throated Green Warbler	17	5
Tennessee Warbler	80	41
Yellow-rumped Warbler	94	63
Bay-breasted Warbler	73	55
Golden-crowned Kinglet	16	12
Ruby-crowned Kinglet	27	25
Blue-headed Vireo	24	25
Boreal Chickadee	29	50
Magnolia Warbler	60	126

ically adapted to foraging in conifers and both their body size and foraging habits impeded foraging in deciduous trees.

Tennessee and Magnolia warblers both used White Birch more than expected. Morse (1989) felt that many songbirds preferred various *Betula* species for mechanical reasons; they had smaller leaves than other trees (especially *Fagus*, *Acer* and *Populus*) and were easier for gleaning songbirds to reach. Other studies have found various species of birch have higher densities of lepidopteran larvae than other trees (Holmes and Robinson 1981; Holmes and Shultz 1986). An insufficient sample size prevented testing of Black-throated Green Warbler's tree species preference. It is notable, however, that 50% of the foraging observations on this species were in White Birch, even though these trees represented only 4% of the available habitat. Other researchers (Holmes and Robinson 1981; Robichaud and Villard 1999) have also found that Black-throated Green Warblers are partial to birch and use it greater than expected by chance alone.

Tennessee Warblers used Balsam Fir less than expected, while Blackburnian and Black-throated Green warblers were never observed in this tree. Although Blackburnian and Black-throated Green warbler use of this tree could not be tested, the fact that Balsam Fir comprised 30% of the available trees suggests that both birds were avoiding it. Blackburnian and Black-throated Green warblers were consistently observed high in the canopy, so Balsam Fir with an average height of 11 ± 5.6 metres may have been too short to attract these species (Cumming 1995). Branch structure may also have played a role in some birds' avoidance of fir. Differences in branch shape have been attributed to several bird species' preference of Red Spruce (*Picea rubens*) over White Spruce (Morse 1989; Parrish 1995). Balsam Fir branches were less ridged than those of White Spruce (personal observation). Birds which preferentially foraged on thin outer twigs appeared to have more difficulty foraging on the tips of Balsam Fir branches than they did in White Spruce (personal observation). This was particularly noticeable in Tennessee Warblers because this species focused most of its foraging activities on the outer twigs and new growth in both coniferous and deciduous trees. In contrast, birds which foraged in many tree zones (Yellow-rumped, Magnolia, and Bay-breasted warblers) appeared to be less affected by branch structure and they used Balsam Fir in proportion to its availability.

Foraging

Boreal Chickadees were the only permanent residents in the study and one of the few passerines that are resident in the boreal forest (Ficken et al. 1996). It is considered an advantage for birds to be flexible in their foraging habits when they live in an unpredictable environment, like the boreal forest (Hunt and Flaspohler 1998). Boreal Chickadees were diverse foragers, using most tree zones and overlapping more than 80% with Ruby-crowned Kinglets and Yellow-rumped, Magnolia, Bay-breasted and Tennessee warblers. Other studies found Boreal Chickadees had an average foraging height of five metres, and used all parts of the tree branch (Sabo and Holmes 1983; Ficken et al. 1996). Similarly, I found Boreal Chickadees foraged at an average height of six metres and showed no significant difference in their use of inner and outer branches. They did however, use the top and bottom of trees less than expected. Boreal Chickadees may have avoided the tops of trees because this zone was heavily used by several other species. Boreal Chickadees have been shown elsewhere to shift their foraging activity lower in the trees due to competition from Black-capped Chickadees (Vassallo and Rice 1981). Boreal Chickadees also tended to forage in small subcanopy trees more than any other species except Magnolia Warblers.

Ruby and Golden-Crowned kinglets were similar in their behaviour; however, Ruby-Crowned Kinglets were usually higher in the trees and were more diverse foragers. Rabenold (1978) found that where Ruby-crowned Kinglets and Golden-crowned Kinglets occurred together, Ruby-crowned Kinglets were more diverse in their foraging activity and occurred higher in the canopy than Golden-crowned Kinglets. Franzreb (1984) felt this was due to social dominance of Ruby-crowned over Golden-crowned kinglets. No interspecific social interactions were observed in this study; however, Ruby-crowned Kinglets were twice as abundant as Golden-crowned Kinglets and may have influenced the behaviour of the latter through numerical dominance.

Large inner and middle branches were favoured by both Blue-headed Vireos and Bay-breasted Warblers; this was an area of the trees that was seldom used by other species. There was only moderate foraging overlap (47%) between Blue-headed Vireos and Bay-breasted Warblers, as they foraged at significantly different heights. Foraging on large inner and middle

branches is similar to the behaviour these two species have displayed elsewhere (Williams 1996; James 1998).

Both Blackburnian and Black-throated Green warblers foraged high in the trees (significantly higher than most other species), and had larger foraging overlap with each other (85%) than they did with any other species. These warblers appeared to be specialized in a tree-top niche, and have been identified in many studies as feeding, singing, and nesting high in coniferous trees (Morse 1993, 1994). Indeed, Morse (1994) found that Blackburnian Warblers were unlikely to be found in forest without at least some conifers over 18 metres tall. Unlike MacArthur (1958) and Morse (1989), I found no evidence that Black-throated Green Warblers were socially dominant over any other species in the study area. This may have been because Black-throated Green Warblers were the least abundant bird in the study and only occurred in one of three study sites.

Similar to their behaviour elsewhere, Tennessee Warblers were observed at a variety of heights in all tree species, but foraged mainly on the terminal foliage (Rimmer and McFarland 1998). Foraging on the tips of the branches and using many different trees may help Tennessee Warblers (a *Vermivora* warbler) fit into a community (spruce-fir forest) that already has several coexisting species of *Dendroica* warblers (Morse 1989). Tennessee Warblers also used White Birch more than any other species except Magnolia and Black-throated Green warblers. Greenburg (1979) felt that small warblers were better able to forage on deciduous foliage than larger warblers for the physical reasons. Tennessee, Magnolia and Black-throated Green warblers were smaller than most species, except for the two kinglets, and Boreal Chickadees, which were conifer specialists. Therefore, they may have been using a food resource that the larger Yellow-rumped and Bay-breasted warblers would have trouble exploiting.

I found Magnolia Warblers used subcanopy trees more than any other species and had the lowest average foraging height of all species observed. This was similar to Hall (1994), who found Magnolia Warblers used mainly young conifers and were seldom found at any great height. Magnolia Warblers displayed no significant difference in their use of inner, middle and outer parts of branches. This was likely because they most often foraged young trees; there was far less difference in branch structure between inner and outer parts of branches in young trees than there was in large old trees (personal observations).

Yellow-rumped Warbler showed the greatest diversity of foraging habits. They used almost every tree zone in both coniferous and deciduous trees. Yellow-rumped Warblers have been noted elsewhere as being generalists and this flexibility is thought to help them withstand adverse conditions better than their congeners (Rabenold 1978; Hunt and Flaspohler 1998). Unlike their behaviour elsewhere (MacArthur 1958; Morse 1989), Yellow-rumped Warblers did not use mainly the bottom and inner branches. Yellow-rumped Warblers occurred most often in the middle and outer branches at mid to upper heights in both conifers and deciduous trees, the same zone frequented by Black-throated Green Warblers in other studies (MacArthur 1958; Morse 1989). Morse (1971) and Howe (1979) felt that the presence or absence of Black-throated Green Warblers caused shifts in Yellow-rumped Warbler foraging activity. I observed no social interactions between Yellow-rumped and Black-throated Green warblers, and as Yellow-rumped Warblers were eight times more abundant, there was likely little interspecific competition between these two species. Indeed, Yellow-rumped Warblers experienced the most overlap, and likely the most interspecific competition, from Magnolia Warblers, Boreal Chickadees, and Ruby-crowned Kinglets (Table 4 and Figure 1).

Niche Overlap

Northern regions, such as the boreal forest, are thought to have such large pulses of seasonally available food that for songbirds food saturation occurs (Rabenold 1983; Wiens 1989). This seasonal pulse of food, combined with a high number of neo-tropical migrants, allows greater niche overlap between songbirds than occurs in other habitats (Rabenold 1978, 1983; Wiens 1989). Rabenold (1978) found that spruce-fir forests in particular had a high number of songbirds which were "...broadly overlapping congeners". Although the present study and Rabenold's were not directly comparable, many of the species were the same between the two studies and results from this study support his theory of generalist stacking. Species with the most generalized foraging behaviour had the highest amount of niche overlap, while those with more specialized foraging behaviour had little niche overlap.

Canopy vs. *Subcanopy*

Availabilty of canopy versus subcanopy trees was not measured; therefore, I could not test whether birds were significantly selecting one over the other. At the two extremes, however, it was apparent that Blackburnian Warblers were using very tall trees almost exclusively, while Magnolia Warblers were using mostly young regenerating trees.

I tested Yellow-rumped Warblers' use of canopy and subcanopy trees against Magnolia Warblers' and Boreal Chickadees' because they had a 95% foraging overlap (in conifers) with both species (83% with Magnolia Warbler in deciduous trees). A Z-test (in results) found Yellow-rumped Warblers used tall (canopy) trees significantly more than the other two species. I felt this was a significant difference between these species, as they used the available habitat in a similar way and they did not forage at significantly different heights. Magnolia and Yellow-rumped warblers were also the two most abundant species in study.

Previous research has shown old-growth boreal mixedwood forest such as those studied here to harbor

unique communities not seen in pre-rotation age forest (Erskine 1977; Kirk et al. 1996: Cumming and Diamond 2002). This diverse songbird community appears to be caused by an interaction between a structurally diverse habitat and a mixture of generalized and specilized foraging behaviours of the bird species involved. Although this study did not examine multiple age classes of forest, it would appear that the community dynamics seen here may be fairly unique due to canopy gap dynamics that tend to be associated with old-growth forest (Hunter 1990). This type and age-class of forest has not received the attention it deserves from either environmental impact studies or long-term management plans for the boreal forest. The scientific community needs to pay greater attention to the contribution old-growth boreal mixedwood forest makes to biodiversity on both a regional and national scale.

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Effects of Mid-winter Snow Depth on Stand Selection by Wolverines, *Gulo gulo luscus,* in the Boreal Forest

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Wolverines (*Gulo gulo luscus*) in a study area in the boreal upland forests of northwestern Alberta and northeastern British Columbia (approximately 57°N) were noted to be limited to upland landscapes, despite abundant food in adjacent lowland landscapes. Snow-tracking suggested that the species was selecting for the densest climax conifer stands for travel in search of food. It was hypothesized that snow depth was a limiting factor for Wolverines in the boreal forest during midwinter, and that they selected for this stand-type because of the buffering effect of this type of canopy on ground snow-depths. A series of snow-depth measurements were collected. Snow depths collected along Wolverine trails were very significantly lower than random snow depths collected under upland canopy ($F = 32.84$, df = 1, $P << 0.010$). There was a significant buffering effect on snow depth indicated for upland canopy ($F = 11.1$, df = 1, $P < 0.010$), while adjacent lowland canopy had no significant buffering effect on snow depth ($F = 3.45$, df = 1, $P > 0.05$). Wolverines were hypothesized to be limited to upland landscapes in the study area because of the buffering effect on snow-depth of the stand types found there, and not for reasons of food availability. Climax conifer stands were interpreted as being of high importance to Wolverine survival during winter. Conservation implications include the detrimental effect on Wolverine populations likely to result from current timber harvesting practices in the boreal forest.

Key Words: Wolverine, *Gulo gulo luscus,* snow depth, boreal forest, stand, landscape, climax, buffering effect, timber harvesting, Alberta, British Columbia.

The Wolverine, *Gulo gulo luscus,* remains among the least understood of the world's forest mesocarnivores. Recent research focusing on the life history of the species in cordilleran landscapes is beginning to fill knowledge gaps. However, landscape features documented as being of high importance to Wolverines in mountainous regions – for example, the alpine zone (Eric Lofroth, personal communication [see Acknowledgments section for affiliation]) – are unavailable to forest populations.

In the boreal forest, Wolverines are believed to be declining from densities that appear to be lower than in any of the other landscapes in which they occur (Banci 1994). As they are less observable in the forest due to the unbroken forest canopy, Wolverine study in the forest ecoprovinces is an even greater challenge than in alpine habitats. It is therefore not surprising that Banci (1994) has suggested that stand-level and landscape scale "habitat use by Wolverines in forests has not been adequately investigated", and that research is needed to study the "habitat needs of Wolverine in forests, because there is no sound basis for developing habitat management prescriptions at the stand level". In forested areas of the northwest, the Wolverine is the furbearer about which wildlife agencies have the greatest concern (Bill Johnson, personal communication).

There has been agreement among researchers that Wolverine "habitat is probably best defined in terms of adequate year-round food supplies in large, sparsely inhabited wilderness areas, rather than in terms of particular types of topography or plant associations" (Kelsall 1981)*. Seasonal shifts by Wolverine in cordilleran landscapes from the alpine zone in the summer to subalpine forest in the winter have been attributed to the availability of food (Banci 1994), or are thought to be related to avoidance of high temperatures or humans (Hornocker and Hash 1981). While snow depth has been investigated as a limiting factor for Fishers, *Martes pennanti* (Krohn et al. 1995; Raine 1983), it has not been implicated as a factor affecting habitat selection in the Wolverine.

This paper presents the hypothesis that Wolverines in the boreal forest are limited by mid-winter snow conditions, which in turn affects stand, and in this case, landscape selection.

Methods

Snow tracking is being increasingly recognized as a reputable scientific tool in wildlife studies, management and conservation, with efforts being made to establish standardized terminology, institute university courses on the subject, and to establish networks of trackers throughout the North American continent (Rezendes 1999; Zielinski and Kucera 1995). Snow tracking may be the only practical way of learning details of Wolverine habits and habitat use, as such details are not adequately provided by radio-telemetry studies (John Krebs, personal communication; Eric Lofroth, personal communication).

Wolverine and other furbearer activities were monitored during three winter seasons (1997-2000) utilizing snow-tracking methods. Approximately 34 000 km were traveled by truck, snowmobile, cross-country skis and on foot, in search of furbearer tracks, with an emphasis on locating Wolverines. The tracking efforts covered approximately 1100 km^2 in the region of the border country of Alberta and British Columbia known as "Chinchaga" (after the Chinchaga River), at approximately 57° north latitude. The tracking area offered conditions especially conducive to this type of study, in that the landscape could be conveniently divided into distinct upland and lowland components. These components offered markedly different and readily divisible stand characteristics as a result of the "Great Chinchaga Fire" which blanketed the area during the 1950s (Don Williams, personal communication), burning all but some upland ridges. Fifty years following the fire, two distinct forest types predominate: early-to-mid seral second-growth of predominantly aspen or pine in the lowlands, with more limited late-seral, climax or "over-mature" stands predominated by White and Black spruce (*Picea* spp.), and mostly dead and dying *Populus* spp. in the uplands. The lowland forest may be further characterized as forming a mosaic broken by broad expanses of relatively open Black spruce fen and willow (*Salix* sp.) muskeg. The upland forest cover is by comparison more continuous.

The area is thoroughly criss-crossed by open linear corridors at varying stages of regeneration that were cleared to conduct seismology work, and have been implicated in possible predator/prey imbalances. Seismology work and subsequent oil and gas exploration and extraction activities have been traditional in the area since the 1950s (Brody 1981). The area is experiencing a surge of such activities at present, and there was virtually no segment of the area covered in tracking Wolverines that was not impacted by these activities at some point during the three winter seasons.

Moose (*Alces alces*) reach some of their highest densities in North America in the area (Brody 1981), being most heavily distributed in the lowlands, and frequent in the uplands. Groups of Woodland Caribou (*Rangifer tarandus caribou*) are frequent at low densities in the lowlands. These are the only two common ungulate species in the region, and they offer a generous prey-base for the area's healthy Grey Wolf (*Canis lupus*) population, whose kills in turn offer a ready food source for the infrequent Wolverines.

When Wolverine tracks were located, the individuals were fore-tracked (older trails) or back-tracked (fresh trails) in order to gain insights into important and little-known details of the creature's use of the boreal forest, including landscape and stand use. Tracks were accessed in the morning by snowmobile or truck, and followed on foot as long as daylight permitted, with the exception of one overnight excursion conducted in order to assess advantages and disadvantages to the tracking process of remaining *in situ*. Pertinent details of the Wolverine's behavior were logged in field notebooks during the tracking event as well as being photographically documented.

Snow depth measurements (in centimetres) were taken over a time frame of approximately 1 week, characterized by below-freezing temperatures, between periods of snowfall. Snow depths were taken at locations determined using random numbers generated by a portable computer (calculator). The number indicated the number of paces to be taken on the ground, either within a grid-square (random snow depths), or along a Wolverine or Lynx (*Lynx canadensis*) trail, at which point a snow-depth was taken.

The following snow-depth data were recorded:

- Ten random depths on open upland sites (to quantify "non-buffered" upland snow depth) with a grid-cell size of 1 km^2;
- 27 random depths in forested upland sites ("buffered" upland depths) with a grid-cell size of 1 km^2;
- Ten random depths on open lowland sites (to quantify non-buffered lowland snow depth) with a grid-cell size of 1 km^2;
- 25 random depths on forested lowland sites (buffered lowland depths) with a grid-cell size of 1 km^2;
- 46 random depths along documented Wolverine trails at random paced intervals;
- 29 random depths along Lynx trails (for comparison purposes) at random paced intervals.

The following comparisons were made utilizing ANOVA tests of significance:

- Snow depths along Wolverine trails *versus* random forested upland snow depths;
- Random forested upland snow depths *versus* random open upland snow depths (= "buffering effect" of upland canopy on snow depth);
- Random forested lowland snow depths *versus* random open lowland snow depths (= buffering effect of lowland canopy on snow depth);
- Snow depths along Lynx trails *versus* random forested lowland snow depths (for comparison purposes).

Crusting of snow typically occurs in the area of this study during late winter to early spring, and occasionally in late fall, depending on temperatures. Crustless (powder) conditions are the norm in this region for the majority of the snow season. Snow conditions were noted as being of a crustless nature during the collection of this data.

Wolverine reactions to linear corridors such as access roads and seismic lines were documented as encountered, with special attention being paid to the effect that snow conditions on the corridors (compacted *versus* undisturbed) had on Wolverine response.

Efforts were made to locate Wolf kills in both representative landscapes in order to monitor such important food sources for utilization by Wolverines.

Results

Wolverine tracks were located on ten occasions over three winters (for a mean of one Wolverine track en-

countered per 3400 km of searching). Thirteen separate tracking events resulted, totaling 20 linear km of off-corridor (forest) tracking, or 26.6 total off-corridor km using Magoun's (1985) estimate of adding 33% to arrive at non-linear distance traveled. Wolverines were tracked for an additional 12.3 km on linear corridors offering conditions of compacted snow, for a total estimated tracking distance of 38.9 km.

Seven Wolf kills (Moose) were located, two in the upland landscape and five in the lowland landscape. These kills were monitored for Wolverine use. An additional road-killed Moose in the lowland landscape was monitored for Wolverine use. Of these, Wolverine were documented as utilizing one of the upland Wolf kills.

Despite frequent available food in the lowland landscape, Wolverine tracks were located only in the upland landscape. Wolverines were revealed to have remained in the uplands throughout the tracking events.

One Wolverine tracked was noted to have traveled through a burned-over upland area regenerating to Lodgepole Pine (*Pinus contorta*). The second-growth pine formed a low (approximately three-metre), dense canopy. Heavy use of the burn by Snowshoe Hares (*Lepus americanus*), provided compacted trails on which the Wolverine traveled through this second-growth.

Wolverines often encountered linear corridors during their travels. Wolverine diverged from their line-of-travel under the forest canopy to travel on 100% of the linear corridors encountered that offered conditions of compacted snow (n=17), for distances ranging from 3 – 3000 m. Wolverines did not travel on any of the corridors encountered that had undisturbed snow cover (n = 16), choosing instead the most direct route across in 100% of instances noted.

There were two instances where an individual Wolverine paralleled an undisturbed east-west corridor from just within the south-facing edge of the canopy. The individual crossed the respective corridors involved to select the south-facing aspect for travels of 470 m and 30 m, before diverging deeper into forest. Exposure to the sun had acted in concert with the buffering effect of the canopy to reduce snow depth from 32 cm on the corridor, to 4 – 11 cm under the canopy's edge.

Snow depths along routes selected for travel by Wolverines were significantly less than random snow depths under the upland canopy ($F = 32.84$, df = 1, $P << 0.010$).

Random upland snow depths under the canopy were significantly less than snow depths in open upland areas ($F = 11.1$, df = 1, $P < 0.010$), whereas random lowland snow depths under canopy were not significantly different from snow depths in open lowland sites ($F = 3.45$, df = 1, $P > 0.05$).

Snow-depths along routes selected for travel by Lynx were not significantly different from random snow depths under the lowland canopy, where Lynx data were collected ($F = 2.86$, df = 1, $P > 0.05$).

When Wolverine tracks were discovered exiting the forest onto access routes, the Wolverines involved had invariably been traveling through dense to extremely dense coniferous cover. While subsequent travel on compacted linear corridors would frequently take a Wolverine through a variety of stand types, the Wolverines invariably selected similarly dense coniferous cover for re-entry into the forest. Within the forest, Wolverines were frequently, even continuously, observed to alter their direction of travel (n = 29) to select for routes that offered an even slightly denser canopy cover (increased buffering effect on snow). Of the random upland sites, 70% were estimated to represent a similar cover type to that selected by Wolverines for travel, as compared to 20% of random lowland sites.

Discussion

Popular and even scientific literature of past decades reflected the level of misconception surrounding the Wolverine. The Wolverine was seen as unique among wildlife in being best adapted to survive during the harshest months, to the point of finding winter a season of ease (Rausch and Pearson 1972). The animal's adaptations to a winter landscape were provided as evidence of this: the dense, luxurious coat (which may give the illusion of good underlying physical condition in winter); the enormous, well-haired "snowshoe" feet cited as enabling the animal to coast effortlessly on top of deep snow; the preference for the harshest wilderness areas. In fact, in an ongoing study in the foothills of northern British Columbia, Wolverines in winter were often found upon examination to be in a state of energetic stress approaching thresholds of starvation (Don Reid, personal communication); a large percentage of dissected Wolverines have empty gastrointestinal tracts (Banci 1994). Unlike such sympatric predators as Martens (*Martes americana*), and coloured foxes (*Vulpes vulpes*), Wolverines are too large to survive on small prey (Banci 1994), and must therefore wander widely, as indicated in all studies, in search

TABLE 1: Comparison of random snow depths

	Wolverine Trails	Random Lowland Locations	Lynx Trails
Range	13 – 47 cm	23 – 52 cm	17 – 54 cm
Mean	31 cm	40 cm	36 cm
Standard Deviation	9.03	7.5	8.2

of less reliable yet more bountiful sources of food such as large ungulate carrion.

While recent research is presenting a different picture of Wolverines and their habits, apparent contradictions still abound. One of the more notable of the apparent contradictions in Wolverine behavior is addressed by this paper: Why do Wolverines select for wide-open landscapes in some parts of their range and the densest of cover in other areas such as the boreal forest? During the tracking of Wolverines in the boreal forest at Chinchaga, patterns of behavior became apparent. The species limited itself to the upland landscape despite abundant food in the lowlands, contradicting literature which suggested that wilderness conditions and a ready supply of food governed the Wolverine's presence or absence, rather than specific landscape and stand features (Kelsall 1981*; Banci 1994). The observation that Wolverines in the study area were limiting themselves to a specific landscape (at least during winter) was supported by conversations with the area's fur trappers and wildlife agents, who noted that:

(1) over many decades of trapper experience in the Chinchaga area, Wolverines were encountered in heavily timbered upland terrain (Les Sharp, personal communication);
(2) in a winter trapper's experience over 13 years on a lowland landscape trapline adjacent to uplands where Wolverines were tracked during this study, not a single Wolverine was caught, nor tracks ever detected (Larry Smith, personal communication).
(3) in other lowland traplines in the area with long traditions of use none were recalled to have ever yielded Wolverine pelts (Bill Johnson, personal communication).

During the tracking efforts, it became quickly apparent to me that the Wolverines were continuously selecting, where feasible, for the path of least snow cover. When faced with even a slight thinning of the forest canopy (= deeper snow conditions), the animals were observed to have paused, selected the densest alternative timber, and altered their route to follow this "path of least resistance" in terms of snow depth. The Wolverines would only cross such openings if:

(1) a compacted Showshoe Hare trail crossed the deeper snow, which they would then select;
(2) alternative routes were not available without extensive detour, in which case the Wolverine would cross the deeper snow over the shortest straight-line path, usually at a walking gait.

Wolverines in the area seemed to favor a "2×" or "3×" lope (Zielinski and Kucera 1995) when less impeded by snow, suggesting that this was their most efficient gait in terms of energy expenditure *versus* distance traveled. They would immediately switch to a less efficient walk, however, when faced with unavoidable stretches of deeper snow.

In comparison, Lynx were observed not to avoid deeper snow, readily crossing open areas of the deepest snow conditions, as encountered. This is supported not only by the snow depth data, which showed Lynx (in direct contrast with Wolverine) to have selected paths of insignificantly less snow depth, but also by the fact that Lynx were abundantly found in the lowland landscape where the buffering effect of the forest canopy was demonstrated to be insignificant.

Wolverines traveling together did so single-file for an estimated 95% of the distance traveled, traveling in tandem only along ridges where snow cover was negligible. It would be interesting to discover if social travel in this species represents a survival strategy, and if the individuals involved alternate as lead-individual.

That Wolverines at Chinchaga were not selecting the densest canopy conditions in order to avoid detection by man or predators is obvious for the following reasons:

(1) In 100% of cases, they followed *open* linear corridors offering compacted snow conditions when encountered (including winter roads up to 18 m wide; freshly opened seismic lines; snowmobile trails; all-terrain vehicle tire tracks; wind-swept ice on creek-beds bisecting open muskeg; compacted otter runways on open creek beds) for travel of distances up to 3 km;
(2) Wolverines are more abundant on the open tundra (characterized by hard-crusted snow conditions) than they are in the forest (Don Reid, personal communication; Banci 1994);
(3) Wolverines seem to prefer the open alpine zones during snow-free seasons in cordilleran landscapes (Whitman et al. 1986; Banci 1994; Don Reid, personal communication; Eric Lofroth, personal communication).

The hypothesis presented by this paper is that Wolverines in the mid-winter boreal forest are limited by snow conditions. Conifer-dominated climax stand types offer the highest buffering effect on snow conditions underfoot. In this study area, such stand-types are only found extensively in upland landscapes, which accounts for the absence of Wolverines in the lowlands, despite abundant food there. Wolverines travel great distances in search of unpredictable food (Banci 1994) while under conditions of energetic stress, necessitating that they pay the strictest attention to energy expenditure while traveling. To travel in conditions of deep powder (unbuffered) snow is to increase risk of starvation, and so such conditions are avoided where alternatives exist. While the relatively enormous feet of the Wolverine, providing low foot loads of 22 g/cm^2 (Knorre 1959) are of great advantage when crusts begin to form (Eric Lofroth, personal communication), they have little effect in the midwinter powder snows of the northwest characterizing this study, as indicated by shifts to an inefficient walking gait in deep, midwinter snow. It is further suggested here that the size of the Wolverine's feet, rather than being an indication of their level of mastery of winter conditions, is instead just the opposite, an adaptation indicative of their extreme level of sensitivity to snow depths as a result of specialized foraging strategies combined with relatively large body size leading to conditions of energetic stress. While one could argue that Lynx, with their equally large feet and specialized foraging strategies,

should therefore show a similar sensitivity to snow depths not indicated in this study, it should be remembered that the Lynx data herein were collected during years of high hare numbers. Perhaps during the low hare cycle, Lynx must also become more sensitive to snow depths.

Conclusions

During midwinter, Wolverines in the boreal upland forests of northwestern Alberta and northeastern British Columbia demonstrate preferences at the stand level and landscape scale that are apparently unrelated to food availability, consistently selecting for stand types that offer the greatest available buffering effect on ground snow depth.

Wolverines require the type of boreal forest habitat considered optimum for Martens, the species with which they may be considered most highly sympatric. However, Wolverines appear to be even more dependent on climax conifer forests during winter than are Martens. Climax conifer cover appears to be of high importance to Wolverines in the boreal forest because of the buffering effect this stand type has on snow depth.

Forest practices that remove climax growth may create conditions that are not conducive to Wolverine conservation. As current logging practices in the boreal forest are geared towards precisely this type of stand removal, timber harvesting may be a key factor in apparent population declines. Conditions following removal of climax cover may not become favorable again for Wolverine habitation for many decades (Don Williams, personal communication). The situation may be improved in the case of immediate regeneration to *Pinus* spp., however, with a *minimum* estimated lapse of 20 years (several Wolverine generations) before conditions become again conducive to Wolverine travel, if not other life history components of this species. Efforts should be made to preserve linkages of climax conifer cover between more extensive areas of intact climax forest habitat.

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Wolverine, *Gulo gulo luscus*, Resting Sites and Caching Behavior in the Boreal Forest

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Wolverine (*Gulo gulo luscus*) caches and resting sites were examined in a study area in the boreal upland forests of northwestern Alberta and northeastern British Columbia (approximately 57°N). Cache sites were in climax, or "overmature" stands of Black Spruce (*Picea mariana*) or mixed-wood of high complexity, dominated by conifers, and in which the Trembling Aspen (*Populus tremuloides*) and Balsam Poplar (*Populus balsamifera*) component consisted of mostly dead or dying trees characteristic of such old growth in the boreal uplands. Sites offered relatively good visibility of the surrounding stand. Sites were never located in the dense to extremely dense homogenous spruce stands documented as being favored for travel by Wolverines in the study area. The better used cache complexes were accessed by numerous well-used trails made by the Wolverines themselves. Caches consisted of the bones, hide and hair of Moose (*Alces alces*) believed to have been killed by Grey Wolves (*Canis lupus*). Caches were classified as "simple caches" composed of a single feeding site and/or excavation and "cache complexes" involving one or more feeding "stations", latrines, resting sites, and climbing trees that may have been used as avenues of escape from competitors/predators. Resting sites were located atop the snow in relatively open locations that offered good visibility of the surroundings. Climax stands were implicated as being of importance to Wolverine caching behavior. Conservation implications include the detrimental effect on Wolverine populations likely to result from current timber harvesting practices in the boreal forest.

Key words: Wolverine, *Gulo gulo luscus,* cache, resting site, climax, boreal forest, stand, Alberta, British Columbia.

Knowledge gaps exist involving many aspects of Wolverine life history in forests, including caching behavior and selection of resting sites (Banci 1994). This paper presents observations of these aspects of Wolverine activities as documented over three winters (1997-2000) of snow-tracking efforts in the boreal upland forests of the border between northwestern Alberta and northeastern British Columbia, at approximately 57°N.

Methods

Wolverine and other furbearer activities were monitored during three winter seasons (1997-2000) utilizing snow-tracking methods. The tracking efforts covered approximately 1100 km^2 in the region of the border country of Alberta and British Columbia known as "Chinchaga" (after the Chinchaga River). Tracking is being increasingly recognized as a useful scientific tool in wildlife studies, management and conservation, with efforts being made to establish standardized terminology, to institute university courses on the subject, and to establish networks of trackers throughout the North American continent (Rezendes 1999; Zielinski and Kucera 1995). Snow tracking may be the only practical way of learning details of Wolverine habits and habitat use, as such details are not adequately provided by radio-telemetry studies (Eric Lofroth, personal communication).

Approximately 34 000 km were traveled by truck, snowmobile, cross-country skis and on foot, in search of furbearer tracks over the course of the three winters, with an emphasis on locating Wolverines. Markedly different and readily divisible stand characteristics are a feature of the area as a result of the "Great Chinchaga Fire" which blanketed the region during the 1950s (Don Williams, personal communication), burning all but the upland ridges. Fifty years following the fire, two distinct forest types predominate: early-to-mid seral second growth of predominantly aspen or pine in the lowlands, with more limited late-seral, climax or "overmature" stands predominated by White Spruce and Black Spruce (*Picea* spp.), and mostly dead and dying *Populus* spp. in the uplands. The lowland forest may be further characterized as forming a mosaic broken by broad expanses of relatively open Black Spruce fen and open Willow (*Salix* spp.) muskeg. The upland forest cover is by comparison more continuous.

Moose (*Alces alces*) reach some of their highest densities in North America in the area (Brody 1981), being most heavily distributed in the lowlands, and frequent in the uplands. Groups of Woodland Caribou (*Rangifer tarandus caribou*) are frequent at low densities in the lowlands. These ungulates offer a generous prey base for the area's healthy Grey Wolf (*Canis lupus*) population, whose kills in turn offer a ready food source for the infrequent Wolverines.

When Wolverine tracks were located, the individuals were fore-tracked (older trails) or back-tracked (fresh trails) in order to gain insights into important and little-known details of the creatures' use of the

boreal forest, including landscape and stand use. Tracks were accessed in the morning by snowmobile or truck, and followed on foot as long as daylight permitted, with the exception of one overnight excursion conducted in order to assess advantages and disadvantages to the tracking process of remaining *in situ*. Pertinent details of the Wolverines' behavior were logged in field notebooks during the tracking event as well as being photographed.

Results

Wolverine tracks were located on ten occasions over three winters (for a mean of one Wolverine track encountered per 3400 km of searching). Thirteen separate tracking events resulted, each lasting approximately six hours, and totaling 20 linear km of off-corridor (forest) tracking, or 26.6 total off-corridor km using Magoun's (1985) estimate of adding 33% to arrive at non-linear distance traveled. Wolverines were tracked for an additional 12.3 km on linear corridors offering conditions of compacted snow, for a total estimated tracking distance of 38.9 km. Five cache sites and three resting sites were encountered and documented using a GPS unit, camera, and sketches in field notebooks.

Despite frequent available food in the lowland landscape, Wolverine tracks were located only in the upland landscape. Wolverine were revealed to have remained in the uplands throughout the tracking events.

Wolverine often encountered linear corridors during their travels. Wolverine diverged from their line of travel under the forest canopy to travel on 100% of the linear corridors encountered that offered conditions of compacted snow (n=17), for distances ranging from 3 to 3000 m. In one instance, two Wolverines traveling together followed a compacted (snowmobile) trail on a linear corridor for 1270 m to bring them within 150 m of a cache site, at which point they exited the trail at right angles to follow the shortest linear distance directly to the cache.

All five caches observed consisted of bones and/or sections of the hides of Moose (*Alces alces*), all of which were believed to have stemmed from the Wolverine's scavenging of Grey Wolf (*Canis lupus*) kills. Bones and hide are believed to be a very important component of the Wolverine's winter economy (Banci 1994; Haynes 1982). Cache-sites appear to be closely frequented until the nutritive value is exhausted, judging from the well-used system of trails and tracks of varying ages in the vicinity of such sites.

Cache sites encountered ranged from those consisting of a single bone process or an excavation (n = 2), to those better described as "cache complexes" (n = 3). Such complexes were believed to stem from the scavenging of a single kill, resulting in a series of smaller caches spread over areas which ranged from highly localized to widely radiating. Cache sites were in climax, or "overmature" stands of Black Spruce (*Picea mariana*) or mixed-wood of high complexity, dominated by conifers in which the Trembling Aspen (*Populus tremuloides*) and Balsam Poplar (*Populus balsamifera*) component consisted of mostly dead or dying individuals characteristic of such old growth in the boreal uplands. Sites offered relatively good visibility of the surrounding stand. Sites were never located in the dense to extremely dense homogenous spruce stands documented as being favored for travel by Wolverines in the study area, perhaps because of the limited field of vision in such stands. The better-used cache complexes were accessed by numerous well-used trails made by the Wolverines themselves, and had certain features in common, including:

- a readily accessible spruce tree (*Picea* spp.) of relatively large dbh (diameter at breast height) selected and well-used for climbing (perhaps as refuge from Wolves, or a safe area to digest between feedings);
- a resting site characterized as a depression in the snow formed by the Wolverine's body and with a good view of surroundings;
- one or more latrines – specific off-trail sites the Wolverine visited to eliminate wastes;
- a radiating series of "feeding areas" characterized by areas approximately 1.5 m^2 of well-compacted snow, on which bones and bone fragments or sections of Moose-hide were found, but not both, and distinguishable from a kill site by the lack of Moose stomach-content remains;
- excavations [often in the snow, but on more than one occasion (n = 3) in the earth beneath the overhanging boughs of a very large spruce tree], that likely had contained fragments of cached food.

A detailed description of the cache and resting sites presented on a site-by-site basis follows, in order as encountered.

Cache # I

Cache # I was a widely radiating cache complex. The original Wolf kill site was believed to have occurred on a linear corridor regenerating to Lodgepole Pine (*Pinus contorta*) located at 57° 27' 20" N and 120° 08' 26" W. Old Wolf tracks lead to and from this central location, and Wolverine trails of varying ages, all apparently more recent than the Wolf tracks, were present. Shards of Moose bone were located at a feeding area here.

Three additional caches connected by Wolverine trails and radiating from the kill site combined to comprise the cache complex.

(1) At 57° 27' 20" N and 120° 08' 18" W a cache consisting of Moose hide remains and an abundance of Moose hair was located.

(2) At 57° 27' 17" N and 120° 08' 18" W a fresh excavation in the earth under the boughs of a very large spruce tree was located. This cache was believed to have been visited by a Wolverine within several hours prior of its discovery.

(3) At 57° 27' 22" N and 120° 08' 06" W a cache consisting of bone shards and fragments was located. The shards were larger than those examined at the kill site. Further components of this cache included an excavation in the snow down to the sphagnum ground-cover and a latrine.

This cache complex was not characterized by a climbing tree, which was a notable component of some other cache sites. The Wolverine tracked to this cache complex was dragging what was believed to be a trap by one of its left feet. This hindrance apparently rendered it incapable of climbing, as nowhere during the tracking event was it observed to have done so, whereas other Wolverines tracked climbed regularly. The trap appeared to affect the individual's locomotion as well; unlike other Wolverines tracked, this individual never varied its gait from a "2× lope" (Zielinski and Kucera 1995).

Cache # II

Cache # II was located 150 m from a linear corridor with compacted access (snowmobile trail) that was followed by two Wolverines traveling together, as mentioned, for 1270 m, before exiting the corridor at a right-angle to head directly to the cache.

This cache is best described as a localized complex, and appeared to represent the richest of the observed caches as evidenced by heavy use. It was located in a climax stand of somewhat stunted Black Spruce. Four feeding stations were located here, characterized by the existence of bone shards and larger fragments and processes of bone. There were three latrines, two containing white scats and one containing brown scats.

Resting Site # 1

A resting site, slightly elevated, was located at the north edge of the complex. The resting site consisted of a 43 × 35 cm oval depression atop the snow, at the base of the remains of a short (30 cm), well-weathered spruce stump. Snow in the depression was well-compacted. The resting site was relatively open, away from the boles of living trees, and offered a good view of the cache complex and its approaches. It was accessed by four well-used trails, at approximately the four points of the compass. A few guard hairs were present in the depression, along with a few dribbles of urine at the edge of the east access.

A climbing tree (Black Spruce) of approximately 14 m was located in a dense clump of smaller spruce at the southeast edge of the cache complex. The tree was larger than the stand's average and heavily used, as evidenced by claw-marks on the trunk, heavy debris of bark atop the snow at the tree's base, and the degree of trampling of snow within the spruce clump. Climbing on the tree appeared to terminate at a point near its apex where there was a "witches' broom" formation estimated to be large enough to support a resting Wolverine; it may have been an additional resting site. No additional trees in the area of the cache complex bore any evidence of having been climbed by a Wolverine.

Resting Site # 2

A second resting site was discovered by following the trail of the two Wolverines after leaving Cache # 2. Approximately 200 m from the cache, this resting site again consisted of an oval depression (58 × 43 cm) atop the snow at the base of a relatively large Tamarack (*Larix laricina*) tree. Snow in the depression was well-compacted. This resting site was characterized by having more canopy cover than the previous site, although the cover was by no means dense. There was no cache in the immediate vicinity of this resting site, and no apparent climbing tree.

Cache # III

Cache # III was located at 57° 26' 84" N and 120° 07' 69" W and is best termed a "simple cache", rather than a cache-complex. This cache consisted of a single large bone-process and a well-gnawed Moose's hoof. The cache was located by following the previous two Wolverines, which evidently were aware of, or scented, this cache, as evidenced by their diverting their course of travel by approximately 50 m to reach the cache. There were no other features characteristic of other caches present at Cache # III.

Cache # IV

Cache # IV located at 57° 27' 25" N and 120° 06' 81" W is best termed a cache-complex, although not extensive. Certain features lacking at the last (simple) cache were present at this one. This cache consisted of a collection of bone fragments located on a single feeding platform under a relatively open canopy in a high-complexity climax mixed-wood stand. The cache was accessed by numerous well-used Wolverine trails. No latrines were discovered at this cache.

Approximately 10 m from the main cache was an excavation in the earth under the overhanging boughs of a very large spruce tree, accessed by a Wolverine trail, and virtually identical to the excavation discovered at Cache # I. This excavation, too, was deemed to have contained cached food that had been recently recovered by a Wolverine.

Cache # IV was further characterized by a well-used climbing tree (spruce) of larger than average dbh, located approximately 4 m from the feeding-station. This cache was located approximately 10 m from a linear corridor with compacted access (snowmobile trail) that was used as a conduit for 700 m in a northerly direction by the Wolverine pair upon exiting the cache. This cache had been visited recently by a Marten (*Martes americana*).

Cache # V

Cache # V was located in very large, climax mixed-wood dominated by spruce, near the base of a ridge adjacent to Resting Site # III. This was a simple cache, consisting of a single fresh excavation in the earth beneath the overhanging boughs of a large spruce, much as described for caches I and IV. The excavation was also believed to be for the purpose of recovering cached food.

Resting Site # 3

Resting Site # 3 was located along the Wolverine pair's trail at 57° 27' 72" N and 120° 05' 11" W. As in the case of the other resting sites observed, this

one consisted of an oval depression atop the snow approximately the same dimensions as the last previous two sites (measurements not taken due to this similarity). The site was mid-slope on a prominent ridge covered by a stand of very large mixed-wood dominated by spruce. The site was relatively open, and offered good view down and along-slope, and only slightly less so upslope. Within 1 m of the resting site was a medium-sized pine tree which had been well-climbed to a height of approximately 4 m.

Tracks indicated that this resting site may have been utilized by a third Wolverine which was traveling down slope. It appeared as though this third Wolverine left the resting site to travel approximately 15 m along-slope to meet the Wolverine pair as they traveled upslope. The single Wolverine may have utilized the climbing-tree to observe the approaching pair. A confusion of tracks resulted where the three Wolverines apparently met. It is believed that all three animals subsequently traveled upslope together.

Discussion

Caches were located in climax stands of less density than those apparently favored for travel by Wolverines in the study area. Visibility of approaching competitors/predators (Wolves) may be the deciding factor in both cache-site and above-snow resting-site selection. That the caches were all located in climax timber reinforces the importance of this stand-type to Wolverine. Present forest practices that result in the harvesting of climax stands may negatively impact Wolverine populations.

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Seasonal Home Ranges of Raccoons, *Procyon lotor*, Using a Common Feeding Site in Rural Eastern Ontario: Rabies Management Implications

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Thirteen adult Raccoons (*Procyon lotor*) (six females, seven males) that fed at a garbage dump north of Kingston, Ontario were radio-tracked from 21 June to 16 October 1995 to assess their seasonal home ranges and movements. Average Minimum Convex Polygon (MCP) summer and fall home ranges for the collared Raccoons were 78.4 ha (SD=46.2 ha) and 45.6 ha (SD=29.7 ha), respectively. Average grid cell summer and fall home ranges for the collared Raccoons were 143.3 ha (SD=40.0 ha) and 116.9 ha (SD=24.9 ha), respectively. Summer ranges of the Raccoons were significantly larger than fall ranges using both the MCP method (P=0.05) and the grid cell method (P=0.073). Yearling Raccoons travelled an average summer maximum distance from the dump of 2608 m (SD=1964, n=3), more than double the distance of adults (≥2 yr) at 1239 m (SD=547, n=10). The population density for the study area in late August 1995 was estimated at 1 Raccoon/12 ha based on an effective area surrounding the dump of 234 ha. Home range and movement data may be useful to design a strategy to control Raccoon rabies in Ontario.

Key Words: Raccoon, *Procyon lotor*, rabies, communal feeding, disease transmission, field study, home range, telemetry, Ontario.

Raccoon (*Procyon lotor*) rabies was first reported in Ontario, Canada, during July 1999 (Wandeler and Salsberg 1999; Rosatte et al. 2001). Point infection control methodologies are currently being used (since 1999) in Ontario to contain the outbreak to a small area (Rosatte et al. 2001). As well, a Raccoon rabies model is being developed in Ontario to assist with the control of the disease by predicting the rate of spread of Raccoon rabies both temporally and spatially. Knowledge on Raccoon home ranges, movements and population dynamics in Ontario is needed to develop and validate the rabies model so that it reflects the actual sequence of events that occur during a Raccoon rabies epizootic/enzootic (Broadfoot et al. 2001).

The spatial distribution of food is known to influence contact rates in Raccoons (*Procyon lotor*) (Seidensticker et al., 1988). Clumped food resources such as garbage dumps may increase potential contact rates of Raccoons as these resources cause members of a population to congregate from a wide area. This in turn may influence rabies transmission in the population (Seidensticker et al. 1988). Range of movements of Raccoons using common feeding sites may be a useful indicator of potential rabies spread. Such information can be used to design effective baiting strategies to vaccinate these animals against rabies as well as provide input for the development of rabies models.

Home ranges of Raccoons tend to shift due to seasonal changes in behavior and therefore must be calculated separately for each season (Kauffmann 1982). Summer is the family rearing period when lactating mothers and their offspring travel together and it is also the main dispersal period for yearling males (Mech et al. 1968; Fritzell 1978). Fall is a time when the juveniles may disperse and Raccoons prepare for the coming winter dormancy period (Shirer and Fitch 1970). In this study, home range was defined using criteria of White and Garrott (1990) as the area within which the animal normally moved in a specified time frame, in this case the summer and fall of 1995.

In this study, movements of Raccoons using a common feeding site in rural eastern Ontario, Canada, were determined by radio-telemetry to assess the size of their summer and fall home ranges. The same Raccoons on which contact data were obtained in the Totton et al. (2002) study were used. In addition, two Raccoons, caught at a smaller feeding site (compost heap) were tracked periodically to determine their daytime resting sites. The population density of Raccoons in this study was also measured as it influences home range and contact rate.

Study Area and Methods

Trapping took place at a private garbage dump (44°34'N, 76°20'W) and at a compost bin on the grounds of the Queen's University Biological Station 40 km north of Kingston, Ontario (44° 35'N, 76° 19'W). The area surrounding the dump consisted of farm land (livestock), forest, marsh, and cottages (most of which were only occupied during the summer). The entire

study area was about 460 ha. Fifteen Raccoons (eight females and seven males) were collared between 20 May and 27 June 1995. Raccoons were captured using Tomahawk #106 (Tomahawk Live-trap Company, Tomahawk, Wisconsin, USA), and Havahart #1079 (Havahart Live Trap Company, Niagara Falls, Ontario, Canada) live-traps. All Raccoons were ear-tagged (numbered size 1 and 2, National Band and Tag Company, Newport, Kentucky), vaccinated against rabies (Imrab® inactivated rabies vaccine, Merieux, Inc., Athens, Georgia, USA) and canine distemper (Fromm D, modified live virus, SOLVAY animal health, Inc., Mendota Heights, Minnesota, USA). They were immobilized by intramuscular injection of ketamine hydrochloride (Rogar/STB Inc., London, Ontario, Canada) and xylazine hydrochloride [Rompun] (Bayvet, Rexdale, Ontario, Canada) [30 mg/kg body weight ketamine, 10:1 ratio ketamine:rompun]. We determined their sex and extracted a first premolar tooth for age determination by cementum analysis (Johnston et al. 1987). Each animal was then fitted with an adjustable radio-collar [151 to 152-Mhz] (Lotek Engineering Inc., Newmarket, Ontario, Canada) and released at its point of capture.

The radio-tracking system consisted of a four-element Yagi antenna, 151 MHz (FM) transmitters mounted on whip antenna collars (Lotek Engineering, Newmarket, Ontario), one programmable hand-held receiver (Lotek model SRX-400; Lotek Engineering, Inc., Newmarket, Ontario) that operated in the 151-152 MHz range, one hand-held compass, and a four-wheel drive pick-up truck. Animals were given at least seven days to acclimatize to their collars before radio-tracking began, in accordance with White and Garrott's (1990) recommendations. The tracking period lasted from 21 June to 16 October 1995 with attempts being made to locate each Raccoon two to three times per week. Since only one telemetry receiver was available, sequential rather than simultaneous bearings had to be taken. A maximum interval between first and last bearings of 10 min was set to minimize telemetry error caused by animal movement (except for bearings taken during the day when the animals were inactive, at which time the interval may have been longer). In a study by Gert and Fritzell (1996), 23% of the locations came from triangulations with between-bearing intervals in excess of 8 min. For this reason, the 10 min cut-off was deemed reasonable for this study.

Continuous radio-tracking (i.e., location of the animals at least every 15 min (Harris et al. 1990)) was not feasible with only one receiver; therefore, for this study, discontinuous tracking was performed. Location estimates were made for each animal three or four times between dusk and dawn at roughly 2-h intervals, and once during the following afternoon to determine daytime resting sites. The tracking schedule was constructed by randomly selecting six of the collared animals trapped at the dump for one given tracking night. The remaining Raccoons were then tracked on the next scheduled night. A different set of Raccoons was randomly chosen for the following tracking night and so on. Dates of tracking nights were randomly selected for each week.

Three types of location estimate techniques were used: scanning, triangulation, and homing. Scanning involved tuning into the collar frequencies of the dump animals while the researcher sat in the middle of the dump area. Data from telemetry accuracy tests indicated a mean transmitter-receiver distance of 240 m± 30 m (n=20) when the signal was picked up at a gain of 10. A Raccoon was therefore considered to be in a radius of this distance from the center of the dump area if its signal was detected from there at a gain of 10 or less. Most of the locations for the dump animals were obtained by triangulation. This technique involves taking directional bearings from two to three different receiver sites at known locations and using these to estimate the true location of a remote transmitter on the animal's collar (White and Garrott 1990).

Accuracy tests were performed to determine the error associated with locations estimated by triangulation in this study. Bearing accuracy has two components: bias (the average difference between the true bearing and the bearing estimated by the receiving system for a series of receiver-transmitter locations), and precision, which is the standard deviation of these errors (White and Garrott 1990). The bias was 9° and was significantly different from 0° (t=3.61, n=63, P<0.001; one sample t-test (Zar 1996)). Therefore 9° was subtracted from all bearings. Precision of the system was ± 20°.

Screening criteria derived from telemetry accuracy tests were applied to all bearings to eliminate errors due to signal bounce. All bearings which did not intersect with other bearings taken on the same transmitter were removed. All bearings taken from receiver sites associated with large errors (high levels of signal bounce) were removed from subsequent analysis. Also, bearings taken when the transmitter-receiver distance was >2000 m were removed. In addition, all locations involving distances between transmitter and receiver of over 1 km were inspected for plausibility.

A computer program called TRIANG was used to estimate animal locations from triangulated bearing pairs and to calculate the distance between receiver and transmitter for each bearing. TRIANG did not compute animal locations when three bearings were taken. In this case, locations were determined by plotting the bearing angles in AutoCAD and estimating the centre of the triangle created by the intersection of the bearings.

Locations for two of the collared Raccoons were usually obtained by homing (White and Garrott 1990). Locations of animals determined by homing are not affected by error in the telemetry system; however, they

are affected by the researcher's ability to pinpoint the den location on a map (White and Garrott 1990). All locations determined by homing in our study were plotted by hand on 1:10 000 maps of the area to ±50 m to obtain Universal Trans Mercator Co-ordinates (UTMC).

Home ranges were estimated using the minimum convex polygon (MCP) method (Mohr 1947), since this is the only home range method that is strictly comparable between studies (Harris et al. 1990). Ranges for both seasons were combined to compare degree of overlap between seasons. Because it is advantageous to use more than one home range estimate technique (Voigt and Tinline 1980), the grid cell method of home range analysis (Siniff and Tester 1965) was also used. Size of the grid cells was chosen to reflect radio fix accuracy based on the results of accuracy tests. In order to enclose the uncertainty area associated with scanning the dump for transmitter signals (and this was larger than the area associated with triangulation) a grid square would have to measure 480 m on each side. Therefore this was the size of grid square (23 ha) used in estimating grid cell home ranges. The grid was oriented by centering a grid square over the dump site.

Summer home ranges were calculated from telemetry data collected in June, July, and August; September and October fixes were used to calculate fall home ranges. Two female Raccoons were excluded from the analysis because insufficient locational fixes (<16) were acquired during the study. A Mann-Whitney U test (Zar 1996) and Statistica Version 6.0 software (StatSoft Inc., Tulsa, Oklahoma) were used to test for statistical differences in Raccoon home range size. Raccoons were grouped into regular and occasional dump visitors based on the number of nights each animal was seen at the dump out of a total of 35 observation nights in a concurrent behavioral study (Totton et al. 2002). Raccoons were defined as regulars if they were observed at the dump on >51% of all observation nights and occasionals if they were seen at the dump on ≤51% of the observation nights. Since only one telemetry receiver was available, and hence discontinuous locational fixes had to be obtained, detailed analysis of the movement patterns of raccoons in this study was not possible.

Trapping to estimate the Raccoon population size took place at the dump from 28 August to 19 September 1995. At this time of year, juveniles are larger and easier to trap and handle than they are earlier in the summer (Seidensticker et al. 1988). The number of Raccoons in the study area was estimated using a modified Petersen Index (Begon 1979). Density of the dump population was not based solely on the area of the trapping site (garbage dump = 2.3 ha) because it was evident from telemetry data that some Raccoons were travelling from a much wider area to feed at the dump. Instead, using the number of Raccoons calculated by the methods above, estimates were made of the crude density of the population as defined by Seidensticker et al. (1988) based on the average maximum width of the dump Raccoons' summer (MCP) home ranges (1530 m). Since Seidensticker et al. (1988) did not specify how this distance was used to calculate overall area, a square was centred over the dump with each side equal to the distance calculated and this was used for calculation of crude density. Its area was 234 ha.

Results

For locations determined by triangulation, distance between the observer and estimated transmitter location ranged from 8.3 m to 1837.9 m and averaged 330.5 m (SD=239.3 m). Uncertainties in Raccoon position for triangulated bearings (tan 20° × trans-receiver distance) ranged from ±3.0 m to ±668.9 m with a mean of ±120.3 m and standard deviation (SD) of 87.1 m (n=1181). Overall locational uncertainty, including that associated with scanning and homing techniques as well as triangulation, was ±146.6 m (n=1110).

No statistical differences were detected between male and female ranges for values calculated using either the MCP method (P=0.78) or the grid cell method (P=0.26). Therefore, male and female data were pooled to compare summer and fall ranges. As well, only three yearlings were trapped at the dump in this study and home range data were available for two of those. Consequently, statistical comparisons between adult and yearling home range sizes were not performed. No differences could be detected between home ranges of Raccoons that regularly versus occasionally visited the dump. Average Minimum Convex Polygon (MCP) summer and fall home ranges for the collared raccoons were 78.4 ha (SD=46.2 ha) and 45.6 ha (SD=29.7 ha), respectively (Table 1). Average MCP summer/fall home range overlap was 31.2 ha (SD=17.2). Average grid cell summer and fall home ranges for the collared Raccoons were 143.3 ha (SD=40.0 ha) and 116.9 ha (SD=24.9 ha), respectively (Table 1). Average grid cell home range overlap between summer and fall was 95.8 ha (SD=27.5). Summer ranges of the Raccoons were significantly larger than fall ranges using both the MCP method (P=0.05) and the grid cell method (P=0.073).

The most widely ranging Raccoon (a male yearling) in the study was originally trapped at the dump on 27 June. It was later located by telemetry near a farmhouse 4 km northeast of the dump on 16 July. By 18 July, it was visually identified at the dump site again where it remained until 8 August. The only other yearling of the dump Raccoons wandered a maximum of 769 m from the dump during the summer. The average distance of the farthest fix from the dump during the summer for the yearling Raccoons was 2608 m (SD=1964, n=3) and for the adults (≥ 2 yr), 1239 m

TABLE 1. Summer (June to August) and fall (September to October) home ranges of 13 Raccoons which fed at a rural Ontario garbage dump and at a compost heap in 1995[1].

Method	Number of fixes (summer) mean (SD)[2]	Summer range (ha) mean (SD)	Number of fixes (fall) mean (SD)	Fall range (ha) mean (SD)	Area of overlap of ranges mean (SD)
MCP	52 (11.2)	78.4 (46.2)	34.1 (9.6)	45.6 (29.7)	31.2 (17.2)
Grid Cell	44 (6.7)	143.3 (40.0)	33 (9.2)	116.9 (24.9)	95.8 (27.5)

[1] n=13 raccoons {7 males – 6 adults and 1 yearling; 6 females – 5 adults (all lactating) and 1 yearling}
[2] SD=Standard Deviation

TABLE 2. Home range, movements and density of Raccoons in different areas of North America

Location	Habitat	Home Range (km^2)	Movements (km)	Density (/km^2)	Reference
Ontario	rural	0.5-4.0	4-45	4-11	Rosatte and MacInnes 1989 Rosatte 2000; Rosatte et al. 2001
North Dakota	rural	0.2-49	1-24	0.5-1	Fritzell 1978; Greenwood 1982
Minnesota	rural	7-12	>3	2-6	Schnell 1970; Mech et al. 1968
Wisconsin					Dorney 1954; Schneider et al. 1971
Toronto	urban	0.4	<1	7-85	Rosatte et al. 1991; Rosatte 2000
Ohio	urban	<0.2	0.4-0.5	45-100	Cauley 1970; Schinner 1969 Hoffmann and Gottschang 1977

(SD=547, n=10) (P=0.31). The Petersen estimate of the number of Raccoons using the dump was 19, with upper and lower 95% confidence limits of 35 and 12 respectively. Crude density was estimated at 1 Raccoon/12 ha.

Discussion

Home ranges of Raccoons in North America are variable (Table 2) but tend to average around 100 to 300 ha (1-3 km^2) (Kauffmann 1982), but may range from 18 to 2560 ha (0.18-25.6 km^2) for adult males in North Dakota, or 5.1 to 372 ha (0.05-3.72 km^2) for adult females (Stuewer 1943; Hoffmann and Gottschang 1977; Fritzell 1978). Urban Raccoons tend to have smaller home ranges than rural Raccoons (Rosatte et al. 1991) (Table 2). Range size may also vary with season, data collection methods and method of home range estimation (Harris et al. 1990). Distribution and abundance of food also affect home range size (Hoffmann and Gottschang 1977). Small home ranges are associated with high population densities and abundant food (Hoffmann and Gottschang 1977). Fall home ranges of Raccoons in this study were found to be significantly smaller than ranges during the summer. This was expected as, during the fall, in northern areas such as Ontario, Raccoon movement is thought to decrease to conserve energy in preparation for the winter denning period (Rosatte 2000). Large movements by Raccoons during the fall, when food sources are not as abundant, would likely result in a net energy loss thereby decreasing the condition of the animal and decreasing the probability of surviving a harsh winter. Movements of Raccoons in this study were smaller than noted in other rural Ontario studies and in other North American jurisdictions (Rosatte 2000; Table 2). That may have been due to the concentrated food sources in the vicinity of the dump in this study. Raccoons have been known to change their movements and home ranges to include new concentrated sources of food; Seidensticker et al. (1988) discovered that within 27 days, 21 of 23 collared Raccoons living in the area had visited their artificial feeding station at least once. The feeding site in their rural study area was 0.5 ha in diameter and attracted Raccoons from a 127 ha area.

Home ranges of male Raccoons tend to be larger than those of females (Stuewer 1943; Fritzell 1978). The explanation as to why no difference was found in this study may have been because either there was no difference (due to abundant food sources at the dump), or the small sample size prevented the difference from being detected. Lack of a difference between home ranges of regular and occasional dump visitors in this study may have been the result of either a true lack of difference or the small sample size involved. It may also be that the definition for "occasional" was not adequate for comparative purposes.

The coarseness of the grid used for grid cell home range analysis in this study may have led to an overestimate of home range sizes based on the fixes obtained in this study (White and Garrott 1990) and would explain why the grid home range estimates were

larger than the MCP estimates. The advantage of the grid cell method over the MCP method is that the grid method takes into account the precision of the telemetry system (White and Garrott 1990). Raccoons in Hoffmann and Gottschang's (1977) study in suburban Ohio with a Raccoon density of 1/1.46 ha had average home ranges of 5.1 ha. Fritzell's (1978) study with a very low density of Raccoons in the spring and summer averaged 2560 ha. Home ranges of Raccoons in previous Ontario studies (densities of 4 – 94/km^2), varied between 50 and 400 ha (Rosatte 2000; Broadfoot et al. 2001). Raccoons in our study fell between these two extremes, though their home ranges appeared to be smaller than average. However, home range estimates obtained from our study data are probably underestimates of actual home ranges because the study animals were monitored discontinuously over only two seasons. In a Niagara-St. Lawrence trap-recapture study, annual movements of Raccoons averaged 10 km and ranged up to 150 km. In a similar Barrie, Ontario, study, nightly movements of 4 km were common (Rosatte 1996*; 2000). Unless Raccoons are tracked continuously with an accurate system for a long period of time (e.g., 1 yr), their movements and home ranges will probably be underestimated.

Radio-telemetry indicated that one yearling male Raccoon occupied two distinct and widely separated areas during the summer of 1995. The fact that no points were located between these two ranges may have been because he traversed the distance between the two areas in the time between tracking nights. The distance between the two discrete areas was 4 km. Raccoons have been known to travel this distance in a single night (Rosatte 1996*). In addition, the main dispersal period for yearling males in some areas is May to June (Fritzell 1978) and this might have inclined this Raccoon to make such a movement if he were dispersing. A second explanation for the yearling male Raccoons' summer home range pattern is that it may have been aided by a vehicle. Raccoons have been known to ride on such vehicles as boats, transport trucks and rail cars (Rosatte et al. 2001).

One yearling female Raccoon did not travel as far from the dump as the yearling male noted above, indicating that it may have been a post-disperser, having immigrated to the dump area the previous fall. Two out of three of the yearlings in this study were found in excess of 2 km from their initial capture site within the same season of their capture; this indicates that the potential for rabies spread in an unvaccinated population using a common feeding site is probably exacerbated by dispersal of the yearlings from the site during the summer. This has been confirmed by Rosatte (unpublished data) in a Raccoon rabies epizootic area in eastern Ontario. As with the home ranges, mentioned above, these movements are probably minimum estimates of actual distances travelled by the dump Raccoons.

Although caution should be exercised in using data from healthy animals to predict the behavior of rabid ones, telemetry studies on two other species indicated that movements of rabid animals are not very different from the movements of healthy ones (Storm and Verts 1966; Artois and Aubert 1985). Storm and Verts (1966) determined that the movements of a radio-tracked rabid Striped Skunk (*Mephitis mephitis*) in its last weeks of life were not statistically different from the movements of non-rabid skunks. Also, a radio-telemetry study by Artois and Aubert (1985) on three wild foxes inoculated with rabies indicated that these animals occupied a comparable home range before and during the phase at which the virus would have been shed. Rosatte (unpublished) found that during a trap-vaccinate-release study in eastern Ontario, movements of rabid Raccoons were not different from movements of non-rabid Raccoons. If the same rules hold true for Raccoons as they do for skunks or foxes, then rabid Raccoons are likely to encounter the same conspecifics as they would while they were healthy. This indicates that data obtained from this study have direct relevance to potential movements of Raccoons in the study population should they become infected with rabies. That is, dispersing yearling Raccoons using the common feeding site would probably be the main vectors spreading the disease into areas beyond the population.

Contact rates for Red Foxes (*Vulpes vulpes*) used in rabies simulation models are estimates of potential contact rates drawn from analysis of home range overlap obtained from radio telemetry data (Blancou et al. 1991). The low precision of the telemetry system used in this study prevented analysis of home range overlap, spatial relationships and potential contact rates. It was not possible to tell, with the coarseness of the grid used for grid cell home range analysis, the potential for Raccoons with overlapping ranges to contact each other. Two Raccoons could be within the same 23-ha grid cell area at the same time and yet be unaware of each other.

Data from this study indicated extensive overlap of home ranges within the population. Territoriality does not normally occur in Raccoons (Kauffmann 1982; Seidensticker et al. 1988) and has only been found for adult males in the spring and summer in North Dakota, at the northern edge of the Raccoons' range and is thought to be due to competition for access to females (Fritzell 1978). Studies from more southern latitudes failed to demonstrate territoriality in Raccoons (Stuewer 1943; Johnson 1970).

Although caution should be used in comparing densities between studies, especially if different methodologies, seasons, and habitats are involved, population densities for Raccoons are usually around one Raccoon per 8-10 ha (Kauffmann 1982) but may range from one Raccoon per 100 ha in North Dakota and northern Ontario (Fritzell 1978; Rosatte 1996*) to one

Raccoon per 0.4 ha in more favourable habitat (Twichell and Dill 1949). In southern Ontario, Raccoon density averaged over 200 plots sampled was one Raccoon/9-33 ha (Rosatte, unpublished) though densities of up to one Raccoon/1.8 ha have been recorded in forested park areas of Scarborough, Ontario (Rosatte et al. 1991). Density for our study area falls within the high end of the average range for Raccoon density in southern Ontario. It should also be noted that in our study, trapping for population estimates occurred at the end of summer when the local population expanded because the young-of-the-year were entering the population.

Causes of mortality for Raccoons include starvation, heavy parasitism, poison, dogs, automobiles, hunting, trapping, canine distemper, and of course, rabies (Mech et al. 1968; Rosatte and MacInnes 1989; Riley et al. 1998; Rosatte et al. 1991; Rosatte 2000); however, the hunting season in this area was from 15 October to 31 December (OMNR 1996*), after Raccoon density was estimated in this study. Thus, trapping and hunting mortalities for the fall had yet to occur. Also, a considerable number of the dump Raccoons were trapped early in the study and vaccinated against rabies and distemper; therefore, the major source of mortality in this population at the time of the study was probably due to collisions with automobiles. Apart from roadway mortality, the death rate of juveniles in this population was probably very low until winter food shortages set in. For this reason, the density estimated for our population probably represents a peak annual value.

Management Implications

Raccoon home range and movement data were used to estimate areas that need to be treated to control Raccoon rabies in Ontario (Rosatte et al. 2001). Intimate knowledge of Raccoon behavior provides benchmarks to consider when determining the width of the population reduction and vaccination zones in order to prevent the spread of Raccoon rabies (Raccoon Rabies Task Force 1992*). These data are also being used to develop a Raccoon rabies model for Ontario which will be capable of predicting the movement of Raccoon rabies over time in the absence or presence of rabies control strategies.

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Status of Marine Turtles in British Columbia Waters: A Reassessment

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Marine turtles in British Columbia have previously been considered off course stragglers. Here we document 20 new reports for Green Turtles, *Chelonia mydas*, and Leatherback Turtles, *Dermochelys coriacea*, for the province. Until recently there had been no concerted effort to acquire data on marine turtle abundance or frequency off British Columbia. Observations presented here allow a reassessment of marine turtle status in British Columbia waters. We suggest Green Turtles and Leatherbacks should be considered rare vagrants and uncommon seasonal residents, respectively, off British Columbia and that they are a natural part of the British Columbia marine environment.

Key Words: Green Turtle, *Chelonia mydas*, Leatherback Turtle, *Dermochelys coriacea*, British Columbia, status.

There are few published reports for marine turtles in British Columbia waters. Marine turtles in the province have generally been considered "straggler[s]" (Kermode 1932) or "off course" (Gregory and Campbell 1984). Nussbaum et al. (1983) ignore marine turtles in their treatment of northwest amphibians and reptiles, and marine turtles are not included in a recent field guide to northwest reptiles "because sea turtles rarely visit these shores" (St. John 2002). During the preparation of a review of the status and conservation of marine turtles in Canadian waters (McAlpine et al. in press) recent occurrences of Green Turtles off British Columbia were encountered (McAlpine et al. 2002). Here we document additional new reports for Green Turtles, *Chelonia mydas*, as well as Leatherback Turtles, *Dermochelys coriacea*, for British Columbia. These new records nearly double the number of published occurrences for marine turtles from the province. When considered in the context of a recent compilation for adjacent Alaska (Hodge and Wing 2000), these observations suggest a reassessment of sea turtle status in British Columbia waters is warranted. The precipitous decline in Pacific Leatherback numbers (Spotila et al. 2000), so serious it has led to a call for a moratorium on long-line fishing in the Pacific Ocean (Anonymous 2002), also provides a timely context.

Based on terms used to document bird status in Alaska, Wing and Hodge (2002) have proposed a standardized terminology to describe marine turtle occurrences. This terminology, ranging through seven categories from accidental to abundant, is loosely based on number of occurrences only. Although useful, this system ignores the ecological context for occurrence. Here we suggest modifying the system of Wing and Hodge (2002) by adding, where appropriate, one of four descriptors to their categories: resident, seasonal resident, migrant, or vagrant. Resident refers to turtles present year round, seasonal resident refers to turtles present only at certain times of the year, migrant refers to turtles moving through a broad area to another location, vagrant refers to turtles occurring outside their normal resident or migratory range. We use this system, in conjunction with that of Wing and Hodge (2002), to describe marine turtle status in British Columbia.

There are 11 published reports for Green Turtles (Carl 1955; Radovich 1961 cited in Stinson 1984; Hodge and Wing 2000; McAlpine et al. 2002) from British Columbia and 14 reports of Leatherbacks (Kermode 1932; Carl, 1944, 1960; MacAskie and Forester 1962). Published and unpublished marine turtle reports for British Columbia prior to 1982 are summarized in Stinson (1984). Table 1 lists one unpublished British Columbia Green Turtle report, included by Stinson (1984) and six new ones; three unpublished Leatherback reports included in Stinson (1984) and 10 new Leatherback occurrences. There are currently 26 British Columbia reports for the Leatherback accompanied by sufficient locality data to map (McAlpine et al. in press), as well as other reports which are not site-specific. All of the 16 British Columbia Green Turtle reports can be map plotted (McAlpine et al. 2003). Several of the recent Green Turtle records are supported by photographic evidence (Figures 1-3), as are four of the Leatherback sightings (Figure 4; Table 1). The skull in Figure 1 is readily identified as that of *C. mydas* using the figures in Wyneken (2001). This stranding is reported in issue Number 2 of *KSM Wutsiin,* the official newletter of Hartley Bay School. Unfortunately, the skeletal remains of this turtle were not retained. Detailed necropsies carried out on the Green Point and Matlahaw Point *C. mydas* are now archived at the Royal British Columbia Provincial

TABLE 1. Recent occurrences of marine turtles from British Columbia waters.

Date	Location	Latitude(N)	Longitude(W)	Comments
Chelonia mydas				
22 November 1996	Hartley Bay	53° 25'	129° 15'	Carcass, Figure 1
early November 1998	mouth of Tlell R	53° 36'	131° 56'	Carcass, PC[1]: W. Flood to DFM
early November 1998	5 km S of Tlell R	53° 35'	131° 54'	Carcass, PC: W. Flood to DFM
6 November 2001	4 km N of Tlell R	53° 37'	131° 55'	Fresh carcass, carapace 78.7 cm, Figure 2
20 December 2001	Greene Point	49° 03'	125° 43'	Fresh carcass, male, carapace 68.7 cm, Figure 3
21 January 2002	Matlahaw Point	49° 23'	126° 29'	Carcass, male, carapace 69.9 cm
Dermochelys coriacea				
mid-July 1970	Sharbau Island	51° 30'	128° 45'	Stinson (1984)
summer 1977	Off Ucluelet	49° 55'	126° 38'	Stinson (1984)
September 1977	Off Ucluelet	49° 00'	125° 50'	Free swimming, RBCPM photo number 695
30 August 1981	Skidijate Inlet	53° 15'	131° 57'30"	Alive in salmon gillnet, RBCPM photo number 749
1 September 1981	Hectate Strait	53° 20'	130° 30'	Stinson (1984)
16 September 1982	Esperanza Inlet	49° 52'	126° 44'	RBCPM photo number 826
August 1993	Clerke Point	50° 05'	127° 48'	Feeding on *Cyanea*, pc: J. Watson to G. Ellis
26 May 1996	Mt Douglas Park	49° 08'	123° 58'	Free swimming/*Times-Colonist*, 1 June, page B2
May 1997	Kyuquot Sound	50° 05'	127° 13'	Carcass, PC: G. Jamieson to DFM
September 1997	SE of Langara Island	54° 12'	132° 58'	Free swimming, large numbers of *Vellela* sp. present, PC: S. Buchanan to S. Stebbins
Spring 1998	Tofino	49° 07'	125° 53'	Decomposed carcass, PC: to SAO
6 September 2000	off shore	48° 43'18"	127° 26'	Free swimming, PC: K. Morgan to DFM
4 August 2001	off Langara Island	54° 18'	133° 10'	Free swimming, PC: E. Simkin to G. Ellis, Figure 4

[1]PC = personal communication.

FIGURE 1. Skeletal remains of a dead Green Turtle stranded at Hartley Bay, British Columbia, 22 November 1996. The skull in this photo can be readily identified as that of *C. mydas* (Hartley Bay School photo).

Museum and the Strawberry Isle Research Society, Tofino. A report prepared by a veterinary pathologist following examination of the Green Point Turtle states this turtle died from a bacterial infection to which it may have been predisposed following exposure to environmental stressors, such as low water temperature. The animal was also suffering from a moderately severe case of pneumonia. The Matlahaw turtle appeared healthy and cause of death was not determined.

Gregory and Campbell (1984) suggested the single live Green Turtle from British Columbia reported by Carl (1955) was "probably just off course". On the basis of minimum thermal tolerance in cheloniid turtles and the few additional reports of live *C. mydas*. McAlpine et al. (2002) concurred, considering the species "accidental" in the province. Kermode (1932) identified the Leatherback as a "straggler" in the North Pacific, Carl (1944) reported the species as "wandering" to British Columbia waters, and Cook (1981*) considered Leatherback Turtles observed in Canada were either "migrants or strays".

Stinson (1984), however, suggested occurrences of sea turtles in the northeastern Pacific could not be dismissed as accidental but are influenced by temperature anomalies in the ocean. While she found sightings of marine turtles occur regularly during years of normal ocean temperatures, greater numbers of turtles were observed than expected when sea temperatures were above the mean. Hodge and Wing (2002) noted that in Alaska marine turtle occurrences are almost equally divided between warm-water and normal-water years. Most noteworthy was the complete lack of turtles in cold-water years.

Whether the increased number of recent reports reflects a real increase in the prevalence of marine turtles off British Columbia, or simply increased public awareness and reporting, is unknown. However, based on their standardized occurrence terminology for marine turtles, Wing and Hodge (2002) report that marine turtles occur too often in Alaska waters to be considered accidental. These authors consider marine turtles a natural part of the Alaskan marine environment. Likewise, Stinson (1984) concludes marine turtles are a regular part of the environment in the northeast Pacific. Based on the frequency of reports, Wing and Hodge (2002) considered the Green Turtle and Leatherback Turtle as rare and uncommon, respectively, in Alaska. Stinson (1984) identified a marine turtle season of July to September in the northeast Pacific Ocean and stated September was the critical marine turtle month in British Columbia waters. However, nearly all of her British Columbia marine turtle observations are of Leatherbacks. Currently, the seasonal pattern of occurrence that appears to be emerging, both in British Columbia and Alaska, suggests that *D. coriacea* is indeed most frequent during the July to September period, while *C. mydas* is most likely to be found stranded in the northeast Pacific during October to December. It should be noted that most British Columbia Green Turtle observations have been of stranded turtles, often recently deceased.

Hodge and Wing (2000) observe that the low frequency of hard shell turtles from Alaska waters indicates these turtles are straying beyond their tolerable range, while they consider *Dermochelys* in Alaska as occupying marginal habitat that may not be consistently used from year to year. The accumulating number of marine turtle observations from British Columbia suggests that these species are even more frequent in British Columbia than Alaska. Following

FIGURE 3. This 68.7 cm male Green Turtle came ashore fresh dead at Green Point, Vancouver Island, British Columbia, on 20 December 2001. (P. Clarkson/Parks Canada photo).

FIGURE 2. This 78.7 cm Green Turtle came ashore fresh dead on 6 November 2001, 4 km N of the Tlell River, Queen Charlotte Islands, British Columbia (V. Flood photo).

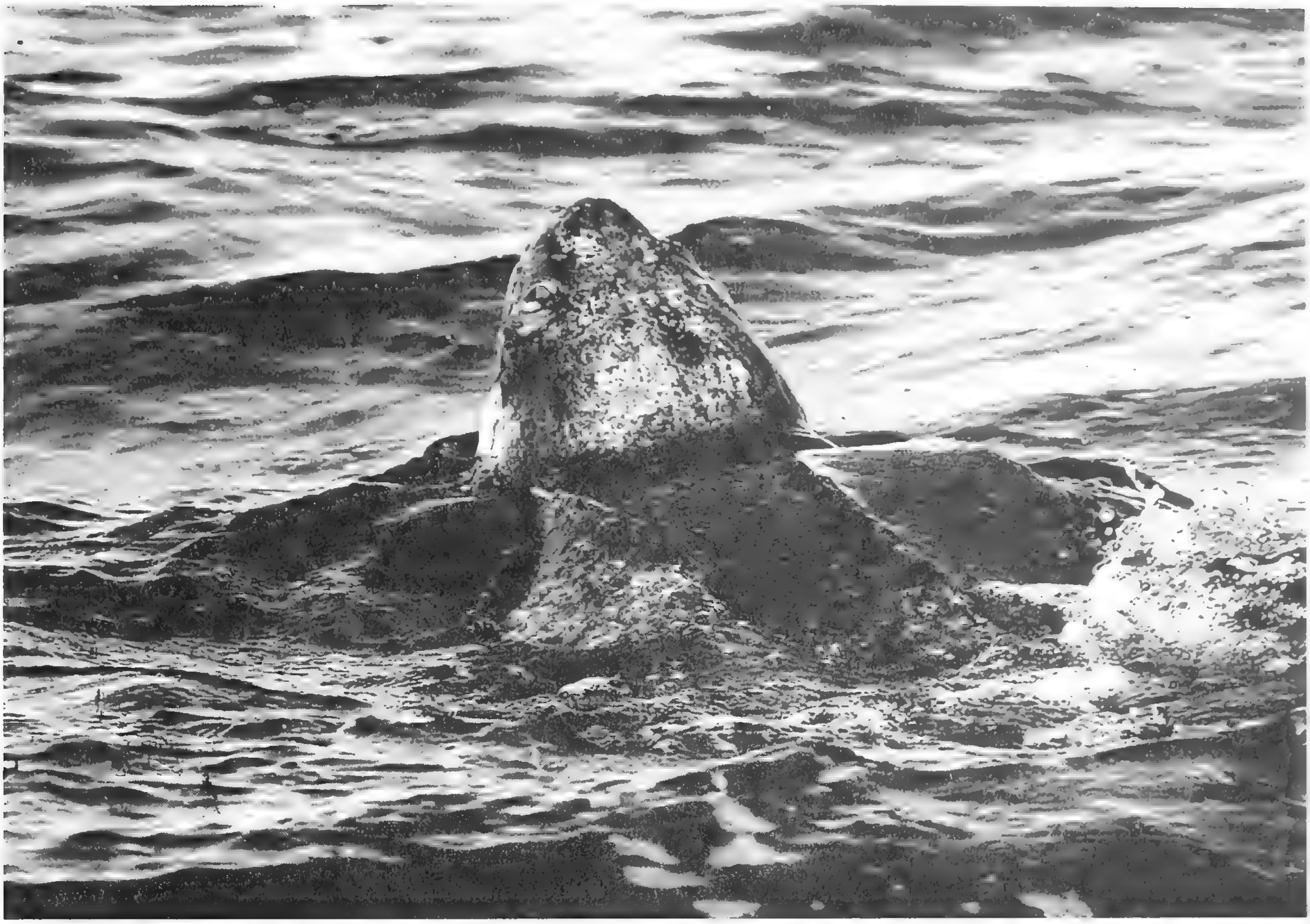

Figure 4. Leatherback turtle photographed 4 August 2001 off Langara Island, Queen Charlotte Islands, British Columbia (Erik Simkin photo).

Wing and Hodge (2002), and our own suggestions above, we describe *C. mydas* as a rare vagrant and and *D. coriacea* as an uncommon seasonal resident in British Columbia waters. However, we would add there has been no effort to methodically collect information from dead stranded turtles nor, until a recent initiative by the Vancouver Aquarium (C. Sbrocchi, personal communication to DFM), to acquire sightings data on marine turtle abundance or frequency off British Columbia. Anecdotal information on several Leatherback occurrences is included in the *KSM Wutsiin* newsletter noted above, indicating canvassing local communities, and especially native fishers, could be a source of information on marine turtle occurrences in British Columbia. Additionally, Glen Jamieson (Pacific Biological Station, personal communication to DFM) reports that Leatherbacks are "periodically seen off the west coast of [Vancouver Island]" and Frank Bernard (Pacific Biological Station, personal communication to SAO) reported that he had seen as many as six Leatherbacks in a day 80-320 km off the west coast of Vancouver Island. Reports of the Pacific Ridley, *Lepidochelys olivacea,* and the Loggerhead, *Caretta caretta,* for Alaska (Hodge and Wing 2000) suggest focused investigations may reveal these species also occur off the British Columbia coast.

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Introduced Marine Species in the Haida Gwaii (Queen Charlotte Islands) Region, British Columbia

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This historical review of a marine area's introduced species was facilitated by geo-referenced marine species inventories of the Haida Gwaii (Queen Charlotte Islands) region. One plant, 14 invertebrate, and two fish introduced species have been recorded since the early 20th century from the marine waters around Haida Gwaii. Records of species occurrences are listed and mapped, and modes of introduction are discussed. It will be important to continue documenting areas' introduced species locations to track the progress of invasions that could affect local marine ecosystem well-being.

Key Words: introduced species, marine, Haida Gwaii, Queen Charlotte Islands, British Columbia.

"*... the control of alien marine species is in its infancy.*" (Bax et al. 2001)

Introduced (non-indigenous) marine species are of global concern (Bax et al. 2001). The dynamism and connectivity of marine ecosystems, mariculture and shipping facilitate species' introductions. The introduction of some species may be followed by rapid local dispersal of propagules and appreciable ecological consequences (Grosholz 2002). Introduced species knowledge is more developed for land and freshwater than for marine ecosystems (Ruiz et al. 2000; Simberloff 2000; Bax et al. 2001).

Carl and Guiguet (1958) were the first to broadly document species introductions in Pacific Canada. Current awareness of the problem is growing in the region, and Levings et al. (2002) have reviewed introduced marine species found in the Strait of Georgia, southern British Columbia.

Using the 30 introduced mollusks along the Pacific coast of North America as an example, Carlton (1992) reported the main modes of introduction as: (1) associated with introduced Japanese and Atlantic oysters imported for mariculture (approximately 27 species), (2) via vessel hull fouling and organisms living in wood, and (3) from overseas ships' ballast water releases. More recently, Chapman et al. (2003) reported that along the U.S. Pacific coast, 24 of the 37 marine and estuarine bivalve species commercially available as seafood are alien species.

We report on the documented presence of introduced marine plants, invertebrates and fishes in the Haida Gwaii (Queen Charlotte Islands) region of northern British Columbia. No introduced marine birds or mammals have been recorded. The plant and invertebrate records, gleaned from the literature and museum collections, are archived in the geographic information system (GIS) databases of Gwaii Haanas National Park Reserve and Haida Heritage Site (Sloan and Bartier 2000; Sloan et al. 2001). We excluded introduced species whose total geographic range encompasses the Haida Gwaii region, although, of course, their presence could be inferred. An example is the amphipod *Corophium acherusicum* from Asia and now known from the northern mainland British Columbia coast (Bousfield and Hoover 1997). The American Shad (*Alosa sapidissima*) have long been known from the whole northeast Pacific (Welander 1940), but only recently from Haida Gwaii waters (Workman et al. 1996). Atlantic salmon (*Salmo salar*) observations were from the Atlantic salmon Watch Program web site: http://www.pac.dfo-mpo.gc.ca/sci/aqua/ASWP_e.htm. The fish records are not yet in our database.

Results and Discussion

For Haida Gwaii, accidental (or active) introductions of one plant, 14 invertebrate, and two fish species associated with fishery or mariculture development are summarized in Table 1 and illustrated in Figures 1 and 2. Likely some of these species have spread northward to Haida Gwaii from the more developed southern mainland British Columbia and U.S. coasts where they first became established. There have been introductions of species to British Columbia targeted for mariculture, such as Pacific Oyster (*Crassostrea gigas*) from Japan, plus their attached associates (Quayle 1988) or parasites (Bower et al. 1994). For example, the seaweed *Sargassum muticum* is now ubiquitous coast-wide, including Haida Gwaii (Figure 1). It was accidentally introduced into southern British Columbia in the early 20th century attached to Pacific oysters. Another example of collateral introduction in British Columbia is the parasitic copepod *Mytilicola orientalis*, likely introduced via Pacific Oyster stock and now widely infesting Native Littleneck Clams (*Protothaca staminea*) and Butter Clams (*Saxidomus giganteus*) in southern British Columbia (Bower et al. 1994).

TABLE 1. Marine plant, invertebrate and fish species recorded from the Haida Gwaii region whose introduction has been accidental or attempted for fisheries development or mariculture. Other bibliographic citations and specimen records for the plant and invertebrate records are cited in Sloan and Bartier (2000) and Sloan *et al.* (2001), archived in Gwaii Haanas' GIS and available from www.marinebiodiversity.ca.

Species	Native Range / *Non-native Range*	Introduction Pathway	History of Expansion in the Northeast Pacific	First Record(s) and Current Distribution around Haida Gwaii	Sources
Plant					
Sargassum Seaweed *Sargassum muticum*	Japan / *SE Alaska to S California, Scandinavia, Netherlands, UK, France, Spain*	Mariculture	Introduced on Japanese oyster shells in the Strait of Georgia and Puget Sound in the 1900s to 1930s; now known from Mexico to Alaska	1981 – Skidegate Inlet; now widespread	Carlton 1979 Druehl 2000 Sloan and Bartier 2000
Invertebrates					
Hydrozoan *Tubularia crocea*	NW Atlantic / *Possibly cosmopolitan*	Shipping[1]	San Francisco Bay, 1859; San Juan Island and Vancouver Island, 1932; N British Columbia, 1911; now known from S California to Alaska	1935 – Houston-Stewart Channel; current distribution unknown	Carlton 1979 Fraser 1936
Oligochaete *Limnodrilus monothecus*	NW Atlantic / *NE Pacific, Mediterranean*	Shipping[1] or Mariculture	San Francisco Bay, 1960; now known from Mexico to British Columbia	1980 – Masset inlet, Parry Passage; current distribution unknown	Cohen and Carlton 1995 Erséus 1982 Sloan et al. 2001
Soft-shell Clam *Mya arenaria*	NW Atlantic / *NE Pacific, North Sea, Black Sea*	Mariculture	San Francisco Bay, 1874; Coos Bay, 1880; Puget Sound by 1889; S British Columbia in the early 1900s; now known from central California to Alaska	1939 – Masset Inlet; 1955 – Naden Harbour; Prior to 1964 – Rennell Sound; now widespread	Carlton 1979 Quayle 1964
Pacific Oyster *Crassostrea gigas*	Japan, Korea, China, SE Asia / *Pacific North America, Europe, Australia*	Mariculture	Puget Sound, 1875; Alaska, 1910; S British Columbia, 1912/13; wild breeding populations established from S British Columbia to Oregon	1957 – Mouth of Kumdis Bay; 1990s – Juveniles[2] taken to raft culture sites in Skidegate Inlet and Rennell Sound	Carlton 1979 Coan et al. 2000
Weathervane × Japanese Scallop Hybrid (*Patinopecten caurinus* × *Mizuhopecten yessoensis*)	NW Pacific (*M. yessoensis* 35°-61°N)	Mariculture	*M. yessoensis* first outplanted in British Columbia in 1988; no breeding populations have established in the wild	1997-2001 hybrid juveniles[2] monitored at pilot raft culture sites in Masset Inlet, off Masset, Skidegate Inlet and Rennell Sound	Harbo 1997
Manila Clam *Venerupis philippinarum*	NW Pacific / *Central British Columbia to N California, Hawaii, Mediterranean*	Mariculture	S British Columbia, 1936; Washington State, 1930s; northern extent is Laredo Sound, British Columbia	1962 – Fisheries and Oceans Canada (DFO) introduced 15,000 each into Masset Inlet and Naden Harbour – none were located in a 1997 survey	Coan et al. 2000 Gillespie and Bourne 1998 Harbo 1997
Snail *Sabia conica*	NW Pacific / *British Columbia*	Shipping[1]	Queen Charlotte Sound, 1940	1963 – Tasu Sound; current distribution unknown	Cowan 1973 Carlton 1979

TABLE 1. (continued)

TABLE 1. *(continued)*

Species	Native Range / *Non-native Range*	Introduction Pathway	History of Expansion in the Northeast Pacific	First Record(s) and Current Distribution around Haida Gwaii	Sources
Amphipod *Ampithoe vallida*	NW Atlantic / *NE Pacific*	Shipping[1] or Mariculture	San Francisco and Tomales Bays, 1941; Coos Bay, 1950; Strait of Georgia, 1973; current distribution unknown, likely common from Oregon northwards	1957 - Masset, Yakoun Bay; Peril Bay and Hotspring Island; 1993 - Burnaby Narrows; current distribution unknown	Carlton 1979 Sloan et al. 2001
Carabid Intertidal Beetle *Trechus obtusus*	Europe / *Europe, Pacific North America*	Nursery Stock	Puget Sound by 1925; currently ranges from Haida Gwaii to California	1980s - Delkatla Inlet; current distribution unknown	Kavanaugh 1992 Kavanaugh and Erwin 1985
Bryozoan *Bowerbankia gracilis*	Atlantic / *Cosmopolitan*	Shipping[1] or Mariculture	Los Angeles Harbour and Tomales Bay, 1940s; Puget Sound prior to 1953; now known from Baja California to Alaska	1976 - Tasu Sound; current distribution unknown	Cohen and Carlton 1995 Sloan et al. 2001
Bryozoan *Cryptosula pallasiana*	N Atlantic / *Cosmopolitan*	Shipping[1] or Mariculture	S California, 1943; San Francisco Bay, 1947; SE Alaska, 1944-1946; Vancouver Island, 1970	1968 - 3 nearshore sites, NW Graham Island; current distribution unknown	Cohen and Carlton 1995 Hines and Ruiz 2000 Sloan et al. 2001
Bryozoan *Schizoporella unicornis*	NW Pacific / *NE Pacific*	Shipping[1] or Mariculture	Washington State, 1927; California, 1938; British Columbia, 1966; now known from Mexico to Alaska	1992 - Anthony Island (SGaang Gwaii); current distribution unknown	Cohen and Carlton 1995 Hines and Ruiz 2000 Sloan et al. 2001
Tunicate *Ciona intestinalis*	N Atlantic / *Cosmopolitan*	Unknown	Unknown, but reported from 15 estuaries in California in 2002	1976 - Tasu Sound; current distribution unknown	California Department of Fish and Game 2002 Ruiz et al. 2000
Tunicate *Pelonaia corrugata*	NW Pacific, Atlantic Arctic / *British Columbia*	Unknown	The only known record is from Haida Gwaii, 1906	1906 - off Rose Spit; current distribution unknown	Austin 1985 Huntsman 1912
Fishes					
Atlantic Salmon *Salmo salar*	N Atlantic / *N Pacific*	Mariculture	Salmon farming began in Washington in the 1970s and British Columbia, 1985; caught in British Columbia waters 1987; natural reproduction in British Columbia, 2000; now known from Washington to Alaska	Records are listed annually by Fisheries and Oceans Canada[3]	McKinnell et al. 1997 Mecklenburg et al. 2002
American Shad *Alosa sapidissima*	NW Atlantic / *E Bering Sea to Baja California*	Mariculture	Sacramento River, 1871; Puget Sound, 1882; Fraser and Stikine Rivers, 1891; Cook Inlet, 1904	Haida Gwaii records are not yet available, likely widespread	Mecklenburg et al. 2002 Welander 1940 Workman et al. 1996

1 introduction through shipping could be from ballast water exchange or hull fouling
2 juveniles are certified disease-free by the commercial supplier
3 http://www.pac.do-mpo.gc.ca/sci/aqua/ASWP_e.htm

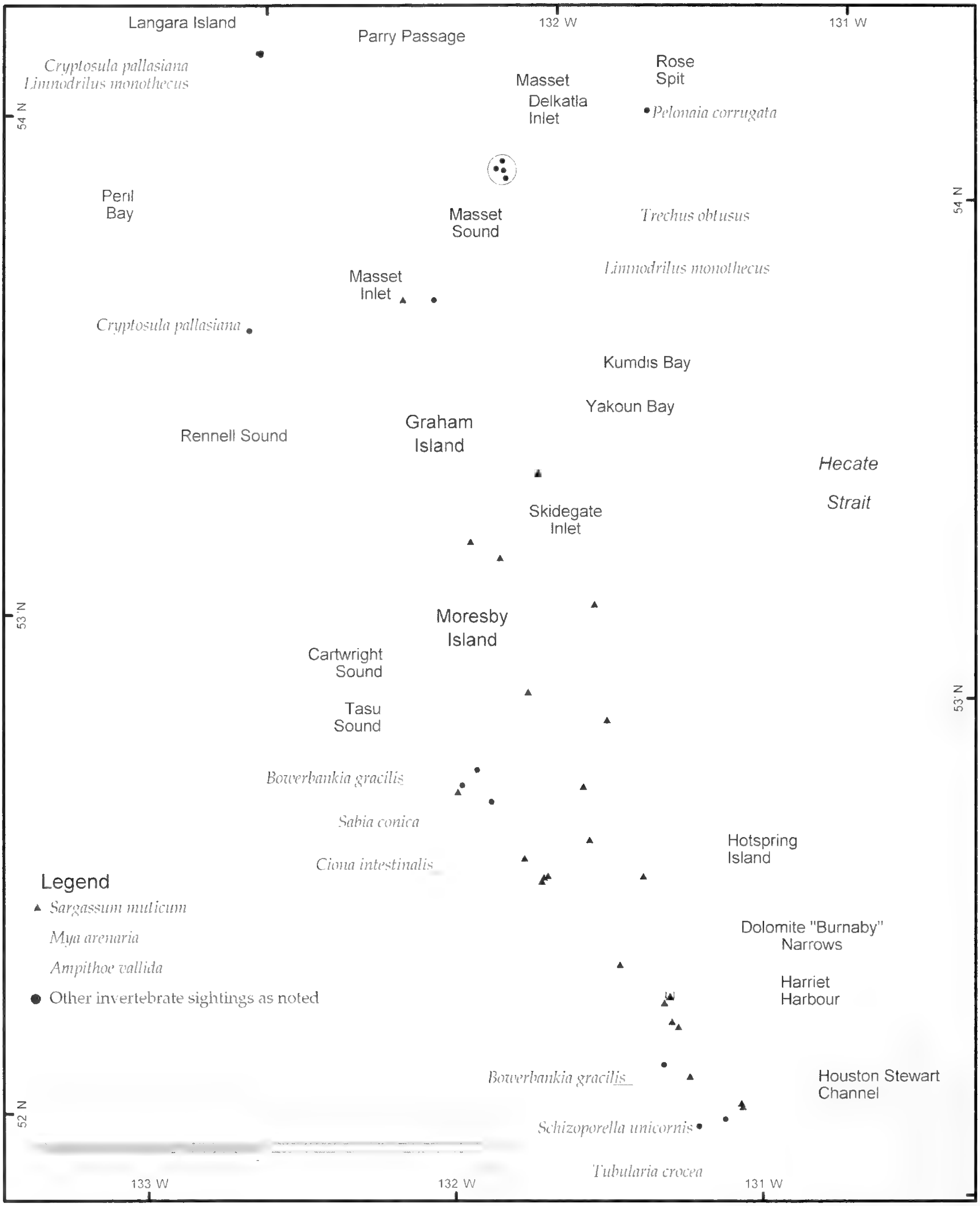

FIGURE 1. Map of Haida Gwaii showing locations mentioned in the text and collection sites of introduced marine plant and invertebrate species, based on data from Sloan and Bartier (2000) and Sloan et al. (2001).

Mariculture-associated Introductions

In 1977, concern over introduced aquatic species issues stimulated establishment of the federal-provincial Fish Transplant Committee (recently renamed Introductions and Transfers Committee – ITC) under mandates from the federal *Fisheries Act* and the *British Columbia Fisheries Act* and *British Columbia Wildlife Act* (BC 1990). The ITC evaluates potential risks to the environment associated with introductions or transfers of either finfish or invertebrates ("shellfish")

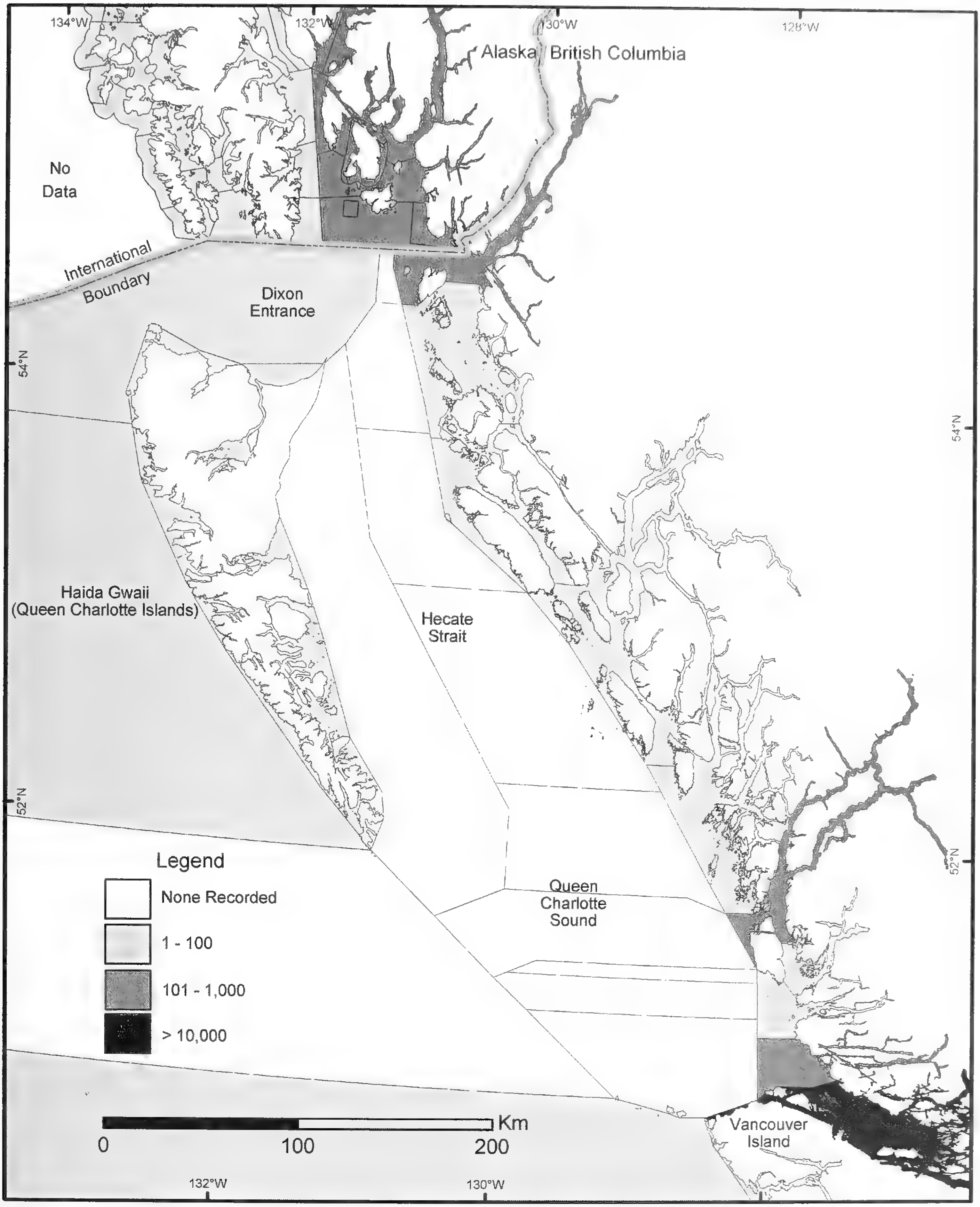

FIGURE 2. Map of the northern British Columbia and southeast Alaska regions showing the density of Atlantic salmon observations. All data are from Fisheries and Oceans Canada's Atlantic Salmon Watch Program: http://www.pac.dfo-mpo.gc.ca/sci/aqua/ASWP_e.htm. [accessed May, 2004]. British Columbia data are from 1987 to 2002 and partitioned according to Pacific Fishery Management Areas, and the Alaska data are from 1990 to 2002 and partitioned according to the Alaska Department of Fish and Game Area Polygons.

into British Columbia marine or freshwaters. Besides the species themselves and their attached associates, there is the risk of introducing diseases, parasites or genetic material into native species. Further, there are concerns over potential ecological displacement of native species. The ITC issues licences to introduce

aquatic species into British Columbia or to transfer species between domestic water bodies.

Shellfish mariculture remains a potential avenue of species introduction to Haida Gwaii. A Masset-based group has investigated the potential for local shellfish mariculture for coastal community economic development. Leased culture operations in Skidegate Inlet and Rennell Sound remain active for Pacific Oyster culture. These operations are unlikely a threat of introducing oysters as local waters are too cold for oyster breeding although they are suitable for growth of certified disease-free juveniles (spat) from culture in southern British Columbia. However, local waters may not be too cold for oysters' parasites or other associated species. From 1997 to 2001, pilot raft culture sites were tested to grow certified disease-free Weathervane Scallop (*Patinopecten* sp.) hybrid (native × Japanese) spat (B. Mark, Masset, personal communication). Only the Rennell Sound site remains active for scallop culture (R. Lozon, Queen Charlotte City, personal communication). The potential for species introduction is likely low, because no successful settlement of hybrid Weathervane Scallops has occurred in British Columbia in the last decade (Island Scallops Ltd., Qualicum Beach, personal communication).

Ships' Ballast Water

Gauthier and Steel (1998) reported that Canada was receiving approximately 52 million tonnes of ballast water from foreign shipping annually with little protective policy or regulation. Indeed, the major vector of introductions to Pacific North America has been from shipping (Ruiz et al. 2000). Concerning Pacific Canada, Levings (1999) mentioned the Canadian Ballast Water Management Guidelines issued by Transport Canada in 2000 with an Annex (II) for the Pacific coast aimed at preventing introduction of non-indigenous aquatic organisms (http://www.tc.gc.ca/MarineSafety/). These Guidelines will become Regulations under the *Canada Shipping Act*.

The Vancouver Port Authority has had a mandatory ballast water program since 1997. It is based on the assumption that mid-ocean ballast water exchange, with water containing pelagic species not likely adapted to coastal conditions, decreases likelihood of introducing viable species into port waters (Levings et al. 2004). Port authorities are now finding, however, that such exchange criteria are only partially effective (C. Levings, Fisheries and Oceans Canada (DFO), personal communication). Other British Columbia ports invoking ballast water management are Nanaimo and New Westminster. The north coast of British Columbia, with an active deep-water international port in Prince Rupert, however, has no ballast water program. Further, Levings et al. (2004) express concern about "intracoastal" transport. For example, from Haida Gwaii there is on-going barge and self-dumping log barge traffic with southern British Columbia and there has been relatively recent international vessel traffic for mine ore concentrates from Tasu Sound (mine closed 1973) and Harriet Harbour (mine closed 1968).

The ecological effects of introduced species such as invertebrates on the Pacific coast are poorly studied (Carlton 1992). It is sobering to reflect that, once introduced, marine species may be difficult to control and their ecosystem consequences may be damaging (Simberloff 2000; Grosholz 2002). An example is the European Green Crab, *Carcinus maenas,* introduced to the San Francisco Bay area in 1989. The Green Crab has since been recorded from Esperanza Inlet on the northwest coast of Vancouver Island (Jamieson et al. 2002). As active predators, Green Crabs could affect British Columbia intertidal fauna, as they have in California (Grosholz 2000).

Times and attitudes have changed about introductions of marine species. In the 1980s, DFO discussed introduction of the large, predatory Atlantic lobster (*Homarus americanus*) around Haida Gwaii. Barber (1983) concluded that up to 7700 km^2 of Hecate Strait area south of Skidegate Inlet, as well as Masset Inlet, were suitable for lobster introduction. Now, such initiatives are contrary to agency mandates for sustainable, ecosystem-based management.

Among introduced marine species, Atlantic Salmon (*Salmo salar*) currently has the highest ecosystem and socio-political profile in British Columbia (Gross 1998; Volpe et al. 2001). Important issues include escapement and persistence in river systems facilitating competition for spawning habitat with native salmonids. Further, the threat of continuing introductions helps animate the vigorous debate over expansion of salmon farming in British Columbia. Although Atlantic Salmon have been reported from Haida Gwaii coastal waters, there are no salmon farms in Haida Gwaii, and there are no records at this time of Atlantic salmon from within Haida Gwaii rivers and streams (V. Fradette, DFO, personal communication).

This overview of a marine region's introduced species was facilitated through marine species inventories from the historical literature of the Haida Gwaii region. We do not claim that it is complete, but it is a start. It will be important to continue documenting introduced species reports to track the progress of introductions that could affect local marine ecosystem well-being.

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Ruby-throated Hummingbird, *Archilochus colubris*, Entanglements in Burdock, *Arctium* spp., at Delta Marsh, Manitoba

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Exotic burdock (*Arctium* spp.) pose a risk of mortality for small native birds, such as the Ruby-throated Hummingbird (*Archilochus colubris*), which may become entangled in its burrs. At Delta Marsh, Manitoba, we found 11 hummingbirds and five individuals of four species of songbirds entangled on burdock in the dune-ridge forest over a 20-year period. Entangled birds were mostly migrants. Most hummingbirds caught were juvenile males, whereas the few songbirds were mostly adult males. We suspect that hummingbird entanglements resulted from an attraction to the purple flowers of burdock, but aggressive interactions with conspecifics and other factors may have been involved. Birds may be at a higher risk of entanglement at important migratory stopover sites, such as Delta Marsh, where both burdock and large numbers of birds are concentrated in a small area.

Key Words: exotic plants, burdock, *Arctium* spp., fatal entanglement, Ruby-throated Hummingbird, *Archilochus colubris*, passerines, mortality, Delta Marsh, Manitoba.

Exotic species often exert negative effects on the survival of native flora and fauna (Atkinson 1989). This is exemplified by the relationship between burdock (*Arctium* spp.) and small birds and bats in North America (McNicholl 1988, 1994). Four species of burdock were introduced from Eurasia into North America in the early 1600s (Gross et al. 1980; Harms 2001). All four species of burdock develop seed heads covered with burrs that stick to passing animals, thus dispersing the seeds (McNicholl 1988). These burrs are hazards for small birds and bats because individuals may become entangled in the hooked bracts and die (McNicholl 1988, 1994). The effect of such entanglements on bird populations may be magnified when the plants are concentrated in small areas where birds nest or forage during migration.

For many songbirds, the dune-ridge forest that separates the south shore of Lake Manitoba from Delta Marsh (50°11' N, 98°19' W), Manitoba, is an important breeding area (Goossen and Sealy 1982; MacKenzie et al. 1982) and migratory stopover site (den Haan 1996). Three species of burdock (*A. minus, A. lappa, A. tomentosum*) have been documented in the area, but Common Burdock (*A. minus*) is the most abundant, occurring along the edge of the marsh and in the ridge forest, as well as in ditches and at other disturbed sites (Shay 1999). The composition of the understory of the ridge forest has changed over the last 30 years and the amount of burdock apparently has increased (Kenkel and Graham 1994; S.G. Sealy, personal observations). With this apparent increase, Delta Marsh has the potential to become a trap line for small birds such as the Ruby-throated Hummingbird (*Archilochus colubris*). Indeed, this species has been one of the most frequently discovered entangled in burdock (McNicholl 1988, 1994; Raloff 1998; Nealen and Nealen 2000). Here we document additional cases of mortality of Ruby-throated Hummingbirds and songbirds due to entrapment on the seed heads of burdock at Delta Marsh, Manitoba.

Entanglements

Sealy and co-workers have studied songbird populations in the ridge forest at Delta Marsh since 1973, but it was not until 1983 that the first bird was found entangled on burdock. The decomposed remains of a Ruby-throated Hummingbird were discovered that spring, but death had occurred the previous year. Since then, 10 more hummingbirds have been found, all but one in August 1985 (Table 1). One of these was alive and released, leaving behind several feathers stuck to the burrs (Table 1). From 1977 to 1979, 1981 and 1983, hummingbirds were banded in conjunction with general songbird banding in the ridge forest from mid-May through the end of August. The timing of the entanglements in 1985 coincided with the fall migration of hummingbirds through the ridge forest in August (Figure1). However, except for the live hummingbird, the dates of entanglement only approximate the time of death because the rates of decomposition and mummification are not known. Thus, some hummingbirds could have been killed earlier in August.

Despite sporadic searching since 1985, only one other entangled hummingbird was found, in 2002 (Table 1, Figure 2), but since 1994, five individuals of four other species have been found entangled fatally (Table 2). Another record consisted of only a few feathers from an unknown passerine species, possibly

TABLE 1. Records of Ruby-throated Hummingbirds entangled in burdock at Delta Marsh, Manitoba.

Date	Age/Sex[1]	Condition	Specimen No.[2]
19 May 1983	Unk/unk	Decomposed: overwintered, wings, ventral feathers attached	4986
15 August 1985	Unk/unk	Released, feathers stuck on burdock	2981[3]
18 August 1985	HY/female	Recently caught (intact)	4982
18 August 1985	HY/male	Recently caught (intact)	4983
18 August 1985	Unk/unk	Partially decomposed: attached by ventral and wing feathers	4985
19 August 1985	HY/female	Recently caught	4981
19 August 1985	AHY/male	Partly decomposed	4984
19 August 1985	AHY/male, HY/male	Facing each other with burrs in between (fresh and mostly intact)	4987 A, B
21 August 1985	HY/male	Stuck across burr (fresh, mostly intact)	4980
14 September 2002	HY/female	Decomposed, sternum visible	4991

[1]Unk = unknown, HY = hatch year, AHY = after hatch year.
[2]Bird specimens deposited in the vertebrate collections of the Manitoba Museum, Winnipeg, Manitoba, Canada.
[3]Feathers deposited in the University of Manitoba Zoology Museum, Winnipeg, Manitoba, Canada.

TABLE 2. Records of songbird species entangled in burdock at Delta Marsh, Manitoba.

Species	Date	Age/Sex[1]	Condition	Specimen No.[2]
Unknown passerine	15 August 1985	Unk/unk	Feathers stuck on burr	2982[3]
Golden-crowned Kinglet	30 October 1994	Unk/male	Wings and breast attached (fairly intact)	4976
Ruby-crowned Kinglet	2 November 1996	AHY/male	Left wing caught (fresh, intact)	4977
Common Yellowthroat	May 1999	AHY/female	Decomposed: overwintered, caught by one leg	4978
	13 May 2000	AHY/male	Decomposed: overwintered, caught by breast, both wings	4979
Yellow-rumped Warbler[4]	10 October 2002	HY/unk	Fresh, caught by right foot, feathers of right flank, left wing	4988

[1]Unk = unknown, HY = hatch year, AHY = after hatch year.
[2]Bird specimens deposited in the vertebrate collections of the Manitoba Museum, Winnipeg, Manitoba, Canada.
[3]Feathers deposited in the University of Manitoba Zoology Museum, Winnipeg, Manitoba, Canada.
[4]Banded 14 September 2002.

a sparrow (C. Dove, personal communication). This bird may have become entangled and freed itself; alternatively it may have been preyed upon or scavenged. Two Common Yellowthroats (*Geothlypis trichas*), a species that nests at Delta Marsh, were found in spring after apparently becoming entangled the previous year. One Golden-crowned Kinglet (*Regulus satrapa*) and one Ruby-crowned Kinglet (*R. calendula*), both boreal forest breeders and late migrants, were found freshly dead in the fall. In October 2002, a freshly dead Yellow-rumped Warbler (*Dendroica coronata*) was discovered less than one month after it had been banded in the ridge forest. All four of these species have been found trapped on burdock elsewhere (McNicholl 1988, 1994).

The sex and age of birds were identified where possible by characteristics of the plumage, feathers and bills (Pyle 1997). Of the hummingbirds entangled, five were males and three were females, whereas three songbirds were males and one was a female (Tables 1, 2). Six hummingbirds were juveniles and two were adults (Table 1). By contrast, three songbirds were adults and only one was a juvenile (Table 2).

Discussion

Most birds entangled in burdock at Delta Marsh likely were migrants. Although Ruby-throated Hummingbirds nest at Delta Marsh (Underwood and den Haan 2000) in small numbers, all entanglements were discovered during their fall migration period through Delta Marsh (Figure 1). Among the other species killed on burdock, only the Common Yellowthroat breeds commonly at Delta Marsh (Underwood and den Haan 2000). The preponderance of migrants in our sample of burdock mortalities is interesting. Several small songbirds, such as the Least Flycather (*Empidonax minimus)* and Yellow Warbler (*Dendroica petechia*), nest at high densities in the ridge forest (Goossen and Sealy 1982; Briskie and Sealy 1989; S. G. Sealy, unpublished data), but neither species has been recorded entangled in burdock there, although the Least Flycatcher is a documented victim elsewhere (Underwood and Underwood 2001). Individuals of both species have been observed perched on stems of burdock (Sealy and Underwood, personal observations) and Sealy observed two male Yellow Warblers, one chasing the other

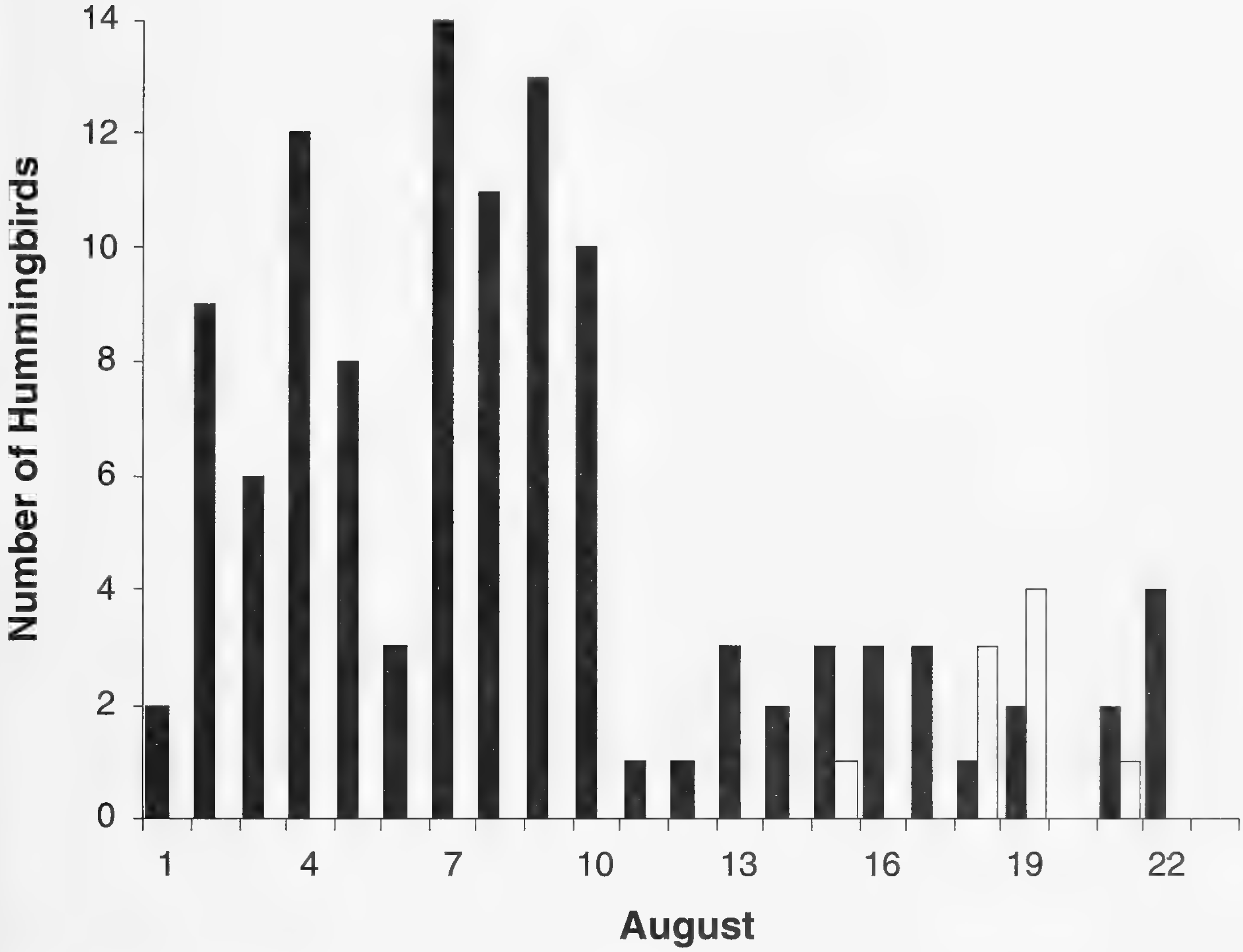

FIGURE 1. Number of Ruby-throated Hummingbirds found caught on burdock at Delta Marsh, August 1985 (n = 9), in relation to the number of hummingbirds banded per day throughout 1977 (n = 7), 1978 (n = 37) and 1979 (n = 4), 1981 (n = 23) and 1982 (n = 42).

that hit seed heads during the chase. Although they became stuck, they extricated themselves within seconds of impact. This observation notwithstanding, accidental strikes on burdock seed heads likely account for few mortalities. This may explain the infrequency of entanglements among the resident songbirds, which have not been observed foraging on burdock flowers or arthropods attracted to them.

It is commonly assumed that birds become entangled while foraging (McNicholl 1988). Although hummingbirds feed mainly while hovering (Robinson et al. 1996), their small size may be the reason they frequently become entangled. As noted by Nealen and Nealen (2000), Ruby-throated Hummingbirds prefer reddish flowers (Robinson et al. 1996; but see Miller and Miller 1971), although they do not specialize on a particular species (Bertin 1982). Because burdock flowers are within the red spectrum (Gross et al. 1980), hummingbirds may be attracted to them in the ridge forest where there are few of the hummingbird's putatively preferred species (Robinson et al. 1996; Shay 1999).

Birds may also become entangled while foraging for insects that inhabit the flowers or the seed heads. Insects may comprise up to 60% of the diet of Ruby-throated Hummingbirds and individuals have been known to glean larval lepidoptera and other insects from the surface of plants (Robinson et al. 1996). Over 20 species of insects from three Orders, Lepidoptera, Coleoptera and Hymenoptera, have been found on burdock seed heads (Mulligan and Kevan 1973; Gross et al. 1980). The kinglets and warblers may have been attempting to take insects from the burrs when they became entangled (see Needham 1909).

Entanglements may also result from social interactions between individuals. The deaths of two male hummingbirds on the same burr cluster (Table 1, MM 4987A and B) may have resulted when one individual attacked the other at the flower cluster and they both became entangled as the interaction ensued. Sealy watched a male Ruby-throated Hummingbird attack another male as it hovered by a seed head. The hovering bird became entangled by one leg, but extricated itself within seconds. The attacker had already flown away. Wind may also cause entanglements, buffeting birds against seed heads as they move through the area (McNicholl 1988). Thus, identifying the factor or combination of factors that promote individual bird entanglements is difficult.

FIGURE 2. Ruby-throated Hummingbird entangled in burdock found 14 September 2002, Delta Marsh (photograph by T. J. Underwood).

The large number of hummingbird entanglements in burdock over a short period in August 1985 seems unusual. Burdock apparently has increased in abundance on the ridge forest (Kenkel and Graham 1994) since our studies began at Delta in 1973. This suggests that the frequency of entanglement should have increased or at least remained constant. However, search effort has varied widely since 1985 and migration rates and weather patterns affecting bird movements through the ridge forest vary from year to year. Hence, it is difficult to assess from occasional records the overall effect of burdock at Delta Marsh on migrating birds. Nevertheless, the growing number of reports of burdock-related deaths in birds (e.g., McNicholl 1994; Raloff 1998; Underwood and Underwood 2001) suggests that this type of mortality may be more important than originally believed, particularly at places like Delta Marsh, and King's Park in Winnipeg (Underwood and Underwood 2001), where burdock and large numbers of migrating birds are concentrated. Further study of the interaction between birds and burdock and the possibly fatal consequences for birds should result in a better understanding of the effects of this exotic plant species on bird populations.

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Multiple Mating Results in Multiple Paternity in Richardson's Ground Squirrels, *Spermophilus richardsonii*

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Hare, James F., Glenda Todd, and Wendy A. Untereiner. 2004. Multiple mating results in multiple paternity in Richardson's Ground Squirrels, *Spermophilus richardsonii*. Canadian Field-Naturalist 118(1): 90-94.

Microsatellite DNA primers developed from Columbian Ground Squirrels (*Spermophilus columbianus*) were used to establish paternity in a Manitoba population of Richardson's Ground Squirrels (*Spermophilus richardsonii*). Primers resolving variation at six microsatellite loci allowed ascription of paternity to 32 of 85 offspring born among litters of 15 breeding females sampled. While the failure to unambiguously document paternity for all juveniles precludes the use of these data to address questions of sperm competition and male mating success, the results do provide direct evidence that multiple mating by female Richardson's Ground Squirrels results in multiple paternity within litters.

Key Words: Richardson's Ground Squirrel, *Spermophilus richardsonii*, mating, microsatellite DNA, multiple paternity, Manitoba.

Differences in gamete size, and hence the differential investment made in gametes by males and female ultimately define the sexes (Parker et al. 1972) and have promoted the evolution of disparate reproductive strategies. Males commonly enhance their fitness by obtaining copulations with more than one female (Bateman 1948), maximizing the propagation of like copies of their genes by siring as many offspring as possible. Conversely, the enhancement of female fitness is typically achieved through choosiness, whereby females mate only with males providing the greatest access to resources (Verner and Willson 1966; Thornhill 1976; Stanford 1995) and/or who are the most fit and contribute good genes to the female's progeny (Zahavi 1975; Weatherhead and Robertson 1979; Hamilton and Zuk 1982). At a proximate level, anisogamy also promotes sex-differential mating behaviour. The relatively few, large, nutrient-rich eggs produced by females necessitate only a single male ejaculate containing vast numbers of small, nutrient-poor spermatozoans to achieve fertilization, and thus female reproductive success may not increase through multiple mating.

Despite these fundamental predictions following from anisogamy, multiple mating by females is common in animals and can prove beneficial to females for various reasons. Obtaining multiple male mates may ensure fertilization (Hoogland 1998), enhance access to resources (Gray 1997), promote parental care on the part of males (Davies et al. 1996), confuse males as to paternity and thus reduce the probability of infanticide (Hrdy 1977), increase female fitness by ensuring genetic compatibility between the female's eggs and at least some of the sperm (Zeh and Zeh 1996) or incite sperm competition (Gomendio and Roldan 1993), whereby the fitness of the female's offspring is enhanced by virtue of the good genes contributed by the victorious spermatozoans (Evans and Magurran 2000).

Where multiple mating occurs, it is critical to understand its implications to both males and females. Advances in molecular biology have revolutionized the study of reproductive behaviour, and revealed that observations of male/female association and mating behaviour may not be representative of parentage in free-living animal populations (Quinn et al. 1987). Methods for determining parentage (see Fleischer 1996 for a review) have also become more powerful and accessible, thereby providing researchers with an opportunity to obtain comparative data which address both the proximate and ultimate questions pertaining to reproductive behaviour.

Such a comparative picture has begun to emerge for the ground-dwelling squirrels (*Spermophilus* spp.), where multiple mating commonly results in multiple paternity within litters, and the first male to mate with a given female often sires a disproportionate number of offspring within a litter. Hanken and Sherman (1981) reported that 78% of 27 Belding's Ground Squirrel (*S. beldingi*) litters for which paternity could be determined using polymorphic blood proteins were multiply sired by between two and three males. Similarly, 50% of eight Thirteen-lined Ground Squirrel (*S. tridecemlineatus*) litters were sired multiply, with the first male to mate siring 75% of offspring in those litters (Foltz and Schwagmeyer 1989). Boellstorff et al. (1994) detected multiple paternity in 88.9% of nine litters of California Ground Squirrels (*S. beecheyi*) and Murie (1995) reported multiple paternity in 15.8% of 165 Columbian Ground Squirrel (*S. columbianus*) litters. Murie (1995), however, predicted that his data likely underestimated the incidence of multiple paternity given that only five polymorphic loci were used, and only one of those had more than two alleles. Indeed, using a more comprehensive and variable series of microsatellite primers (Stevens et al. 1997), multiple

paternity was detected in 64% of litters born to female Columbian Ground Squirrels that had mated multiply (Stevens, Strobeck and Murie unpublished data). Of those litters, 77% were sired by two males, 21% by three males, and 2% by four males. Further, there was a distinct first-male advantage, with 65% of the offspring sampled from among 77 litters sired by the first male to mate, and a progressively declining proportion of paternity success for subsequently mating males (Stevens, Strobeck, and Murie unpublished data).

Despite the widespread occurrence of multiple paternity and a first-male mating advantage, deviations from that pattern are apparent among ground squirrels. Using both protein isozymes and DNA fingerprinting (see Burke 1989), Lacey et al. (1997) revealed that multiple paternity among Arctic Ground Squirrels (*S. parryii*) was relatively rare; it occurred in only 1 (9%) of 11 litters examined and the first male to mate sired the majority (90%) of the offspring in that litter. A departure from the first-male mating advantage has been detected in Idaho Ground Squirrels (*S. brunneus*), where Sherman (1989) reported a last-male mating advantage (a minimum of 66 – 100% of pups sired by the last/longest attending male) in the five of seven litters (71.4%) where multiple paternity was evident. Additional data for other *Spermophilus* species will prove useful in determining whether these species are unique in their apparent departures from the general pattern, and thus how these expressions of multiple mating and sperm precedence impact the behaviour and fitness of males and females.

Richardson's Ground Squirrels (*S. richardsonii*) are locally abundant throughout grazed areas of the Great Plains (Michener and Koeppl 1985). Females mate multiply (Michener and McLean 1996), and although this may result in multiple paternity within litters (van Staaden et al. 1994, Michener personal communication), direct evidence of multiple paternity is lacking. Such data would contribute to our understanding of reproductive behaviour, and open new avenues for research into the contributions of paternal kinship to social interactions (e.g., Holmes and Sherman 1982) and patterns of dispersion among relatives in nature. We applied primers developed by Stevens et al. (1997) to prospective parents and offspring from litters of 15 breeding females in a Manitoba population of Richardson's Ground Squirrels to test whether multiple mating results in multiple paternity within litters.

Methods

Study site, research subjects, and sample collection

Research was conducted between 8 April and 26 July 2002 on a 1.5-ha section of a larger 5-ha cattle pasture near Westbourne, Manitoba (50°10.190'N, 98°38.103'W). Richardson's Ground Squirrels on that site were live-trapped in National or Tomahawk traps baited with peanut butter and were marked for permanent identification with numbered metal ear tags (Monel #1 fish fingerling tags). Each squirrel was also given a distinctive mark on its dorsal pelage with black hair dye (Clairol Hydrience 52 Black Pearl). Trapping was conducted during the mating season (12 through 25 April 2002) to determine mating dates of females and to monitor the reproductive condition of all squirrels. After mating had ended, trapping continued to assess gestational progress in females, and a 2-mm tissue punch was taken from one pinna of each adult (10 males, 18 females). Samples were placed in 1.5-ml microcentrifuge tubes in 95% ethanol, and stored at 4 – 7°C prior to DNA extraction and subsequent molecular analysis. Fifteen females for which mating and parturition dates were known, and for whom ear punches had been obtained, and nest-burrow entrances located were chosen to provide litters for paternity analysis. All juveniles in those litters were trapped within three days of their first emergence from their natal burrow, marked with ear tags and dye marks, and tissue sampled as described for adults. Animal research was conducted in accordance with the guidelines for the use of animals in research set forth by the Canadian Council on Animal Care.

Molecular analysis of paternity

Individual ear punches were placed in 1.5-mL microcentrifuge tubes, centrifuged in a speed-vac for 5 min to remove the excess ethanol and digested at 55°C for 4 – 6 hrs in 70 μL of a sterile cell lysis solution (10 mM Tris-HCL, 100 mM EDTA, 2% SDS, pH 8.0) containing 3 – 4 μL Proteinase K (10 mg/mL). Following the addition of 4 μL of RNase A, the tubes were mixed by inversion and incubated at 37°C for 30 min. Proteins were precipitated by adding 23.5 μL of 7.5 M ammonium acetate to each tube of cell lysate and placing the samples on ice for 30 min. Tubes were centrifuged at 14000 rpm for 3 min and the supernatant was transferred to a new 1.5-mL tube containing 70 μL isopropanol. Samples were mixed by inversion, stored at -20°C for several hours and centrifuged at 14000 rpm for 2 min. Following the removal of the supernatant, the pelleted DNA was washed in 75 μL of ice-cold 75% ethanol and centrifuged at 14000 rpm for 1 min. The ethanol was removed with a pipette and the tubes containing the DNA were placed in speed-vac for 5 – 10 min. The dried pellets were rehydrated in 40 μL of sterile TLA buffer (10 mM Tris-HCL, 0.1 mM EDTA, pH 8.0) and stored at -20°C.

Amplifications were performed on a GeneAmp® PCR System 9700 (Applied Biosystems, Foster City, CA) in a 25-μL volume containing ~ 200 ng DNA, 0.8 mM dNTP, PCR buffer (0.1 M Tris-HCl pH 8.3, 0.5 M KCl, 15 mM MgCl, 0.005 g gelatin/10 mL buffer), 0.5 units of Taq polymerase, and 0.2 μM concentrations of each of seven primers (GS3, GS12, GS14, GS20, GS22, GS25, GS26) described by Stevens et al. (1997). The cycling conditions were 94°C for 2 min followed by two cycles of 94°C for 30 s, 58°C for 20 s, 72°C for 5 s, and 33 cycles of 94°C for 15 s, 54°C for

20 s and 72°C for 5 s followed by a final extension at 72°C for 30 s. PCR products were diluted (1:1) with sterile water and 1 µL of each diluted product was resolved by polyacrylamide gel electrophoresis on an ABI 373 Automated Sequencer (Applied Biosystems). Microsatellites were visualized and sized using GeneScan® 3.1 and Genotyper® 2.1 software (Applied Biosystems).

Results

Of the seven primers employed, one (GS22) resulted in multiple banding patterns and was excluded from subsequent analysis. The remaining six primers resolved meaningful variation among individuals and were used in establishing familial relationships among the individuals sampled. Based upon the observed frequencies of the three to six alleles evident at those six loci (Table 1), the probability that two randomly drawn unrelated individuals will be identical at all loci is 1 in 9577 (from equation in Patekau and Strobeck 1994). Further, the probability that an unrelated male will be excluded as sire given knowledge of the mother's genotype is 0.91 (from equation in Chakravarti and Li 1983). All calculations assume that the loci examined are not linked, and provide highly conservative estimates of exclusion given that they are based on pooled data from dams, sires, and their offspring.

Paternity was definitively ascribed to at least one juvenile within litters of all 15 dams included in the study. In total, however, unique identification of the male sire was achieved for only 32 of the 85 juveniles that emerged in those litters. Based upon those identifications, multiple sires were detected in 12 of the 15 litters examined (80%), with a minimum of two sires in 11 and a minimum of three sires in one of those 12 litters (2.1 ± 0.1 sires/litter; mean ± SE).

Discussion

The microsatellite primers developed by Stevens et al. (1997) proved effective in resolving multiple paternity within litters of Richardson's Ground Squirrels. Indeed, with multiple sires in 80% of the 15 litters examined, multiple paternity is at least as common in Richardson's Ground Squirrels as it is in other *Spermophilus* species with the exception of California Ground Squirrels.

Definitive genetic evidence of multiple paternity in the present study suggests that the use of the primers described by Stevens et al. (1997) in future studies of the reproductive and social behaviour of Richardson's Ground Squirrels would prove quite fruitful. In concert with data on mating behaviour of the sort presented in Michener and McLean (1996), such studies could address the outcome of sperm competition and its relation to mating order (Sherman 1989), the role of aggression and male territoriality in affecting male mating success (Schulte-Hostedde and Millar 2002), and the factors underlying mate choice such as the effects of symmetry (Penton-Voak et al. 2001), body size (Gwynne 1981), paternal effort (Huber et al. 2002), and genetic relatedness (Bateson 1983; Chapman and Crespi 1998). The use of these microsatellite loci to assess relatedness among individuals (Queller et al. 1993) would also allow insight into the role paternal kinship plays in influencing social behaviour (Widdig et al. 2002). Additional markers, however, would be necessary to comprehensively document the paternity of each and every individual. Microsatellite primers that were not employed in the present study, such as GS17 and GS34 (Stevens et al. 1997) or the 13 Idaho Ground Squirrel microsatellite primers described by May et al. (1997), would likely prove useful in this regard.

The alleles identified in our Manitoba population (Table 1) differ from those described for the Richardson's Ground Squirrels examined by Stevens et al. (1997) in evaluating the efficacy of their primers on other Sciurids (see Table 2 in Stevens et al. 1997). Given that geographic variation, the primers employed here should also prove useful for studies of dispersal (Chapuisat et al. 1997), interpopulation differences related to conservation efforts (Patekau and Strobeck 1994), and perhaps even in refining the taxonomy of the ground-dwelling squirrels (Gill and Yensen 1992).

TABLE 1: Characteristics of microsatellite loci (from Stevens et al. 1997) applied in paternity analysis of Richardson's Ground Squirrels. Results are based upon allele frequencies from 10 adult male, 15 adult female, and 85 juvenile squirrels. Expected heterozygosity and probability of identity were calculated according to formulae presented in Patekau and Strobeck (1994), and probability of exclusion was calculated following the methods of Chakravarti and Li (1983).

Locus	Alleles	Expected heterozygosity	Probability of identity	Probability of exclusion
GS3	227, 229, 231, 233	0.630	0.178	0.347
GS12	147, 149, 152, 154	0.672	0.128	0.416
GS14	242, 244, 246	0.549	0.298	0.253
GS20	220, 222, 237	0.105	0.803	0.053
GS25	138, 142, 144, 146, 148, 154	0.769	0.057	0.557
GS26	109, 111, 113, 115	0.480	0.336	0.232

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Demographic Patterns and Limitation of Grey Wolves, *Canis lupus*, in and Near Pukaskwa National Park, Ontario

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In response to concern regarding the growth and long-term viability of the wolf population in and near Pukaskwa National Park, a study of demographic patterns and limitation of radio-collared wolves (*Canis lupus*) was completed between 1994 and 1998. The mean annual finite rate of increase (0.96) suggested that population growth of wolves was limited and declining slightly. Small pack sizes, high cumulative mortality, and low reproductive success also suggested a declining population. Two limiting factors, ungulate biomass and human-caused mortality, were examined to determine the importance of each in limiting the population growth of wolves. Ungulate biomass was involved because occurrence of natural-caused mortality was high (9 of 17 wolves) compared with other studies. In addition, consumption rates were low and similar to other studies where starvation and other signs of malnutrition were noted. Further, Moose densities in the study area were low to moderate and below thresholds indicating nutritional stress for wolves. Occurrence of human-caused mortality was high (8 of 17 wolves) suggesting that it was also an important limiting factor, particularly given the low availability of ungulate biomass and reproduction noted in this study. Based on present demographic patterns, ungulate biomass, and human-caused mortality, the wolf population likely will remain at present low densities or continue to decline.

Key Words: *Canis lupus*, wolves, limitation, demographic patterns, Pukaskwa National Park, Ontario.

In 1996, researchers in the Greater Pukaskwa Ecosystem (GPE) (Figure 1) in Ontario postulated that two limiting factors were negatively affecting the growth and long-term viability of the Grey Wolf *(Canis lupus)* population (Burrows et al. 1996*). These limiting factors were low availability of ungulate prey and high mortality from human causes. Managers in Parks Canada Agency were concerned because wolves are a native species in the GPE. Thus, Parks is legislated to protect and further, to ensure the long-term viability of that population (Parks Canada 2000). This prompted a study of wolves in the western half of the GPE, including Pukaskwa National Park (PNP).

In this paper, we quantify population limitation of wolves and examine the importance of ungulate biomass and human-caused mortality in limiting the population growth of wolves, 1994-1998. For these purposes, we review and discuss demographic data on wolf densities, population growth, reproduction, and mortality. Further, we report and discuss data on the availability of prey and rates of kill and consumption.

* References marked with asterix (*) are listed in a separate Documents Cited section following Acknowledgements, all others are in Literature Cited.

Study Area

The study area comprised 4500 km^2 in the western half of the GPE on the north shore of Lake Superior in Ontario (48°N and 85°W) (Figure 1). The area includes PNP (1878 km^2) but also adjacent land with intensive forestry, gold mines, towns and associated infrastructure.

Two distinct physiographic regions, coastal and interior, occur within the study area. The coastal region is characterized by rugged topography with elevations ranging from 189 to 650 m. Many lakes and rivers occur in the area, creating a patchy landscape. The interior region is a flat plateau characterized by a heavily eroded landscape of mountains previously scoured by continental glaciers (Poitevin et al. 1989*).

Mean annual precipitation is 74 cm along the coast and 64 cm inland. Winter and summer temperatures range from –13C° – 14.6C° for the coastal area and –17C° – 15.9C° inland (Poitevin et al. 1989*). Ice cover on Lake Superior ranges annually from 5-100% (Skibicki 1994*).

Vegetation on the coast along Lake Superior and inland is mixed with associations of Balsam Fir (*Abies balsamea*), Jack Pine (*Pinus banksiana*), White Birch (*Betula papyrifera*), White Spruce (*Picea glauca*), Black Spruce (*Picea mariana*), Eastern White Cedar

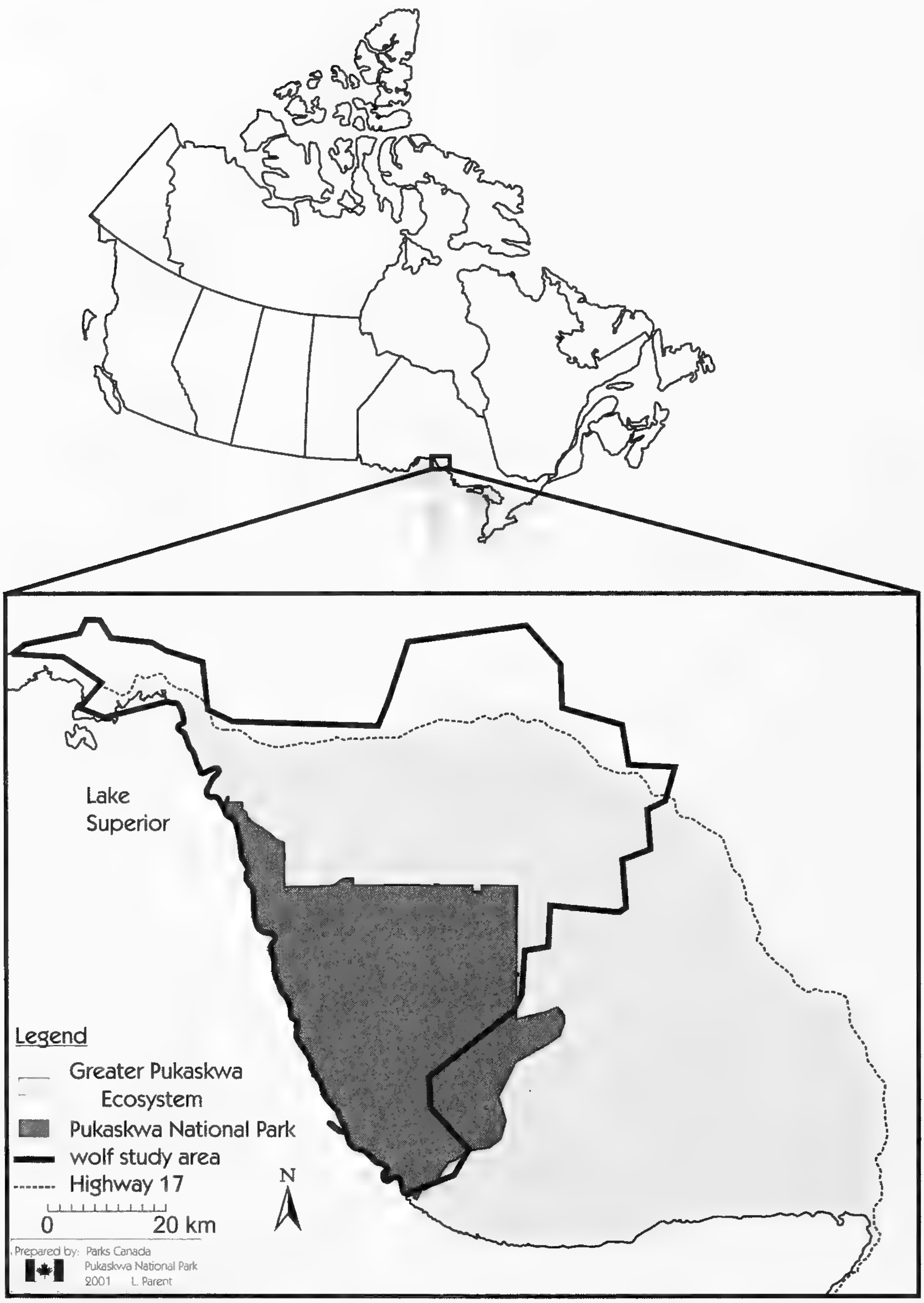

FIGURE 1. Location of the wolf (*Canis lupus*) study area within the Greater Pukaskwa Ecosystem, Ontario, Canada (center 48°N, 85°W).

(*Thuja occidentalis*), and Trembling Aspen (*Populus tremuloides*), with occasional Red Maple (*Acer rubrum*) and other hardwoods more locally abundant in the southeastern corner of the study area.

Predatory mammals included Grey Wolf, Black Bear (*Ursus americanus*), Red Fox (*Vulpes vulpes*), Lynx (*Lynx canadensis*), River Otter (*Lontra canadensis*), Fisher (*Martes pennanti*), American Marten (*Martes americana*), Mink (*Mustela vison*), and Weasels (*Mustela spp.*). Coyotes (*Canis latrans*) were rare except around towns.

Moose (*Alces alces*) were the primary and most abundant ungulate prey species for wolves. Woodland Caribou (*Rangifer tarandus tarandus*) were few and concentrated in small bands along the coast of Lake Superior (Bergerud 1985). Numbers ranged from 6-14 in PNP, 1993-1997 (Wade 1993*, 1995*, 1997*, 1999*). White-tailed Deer (*Odocoileus virginianus*) were rare in the GPE.

Methods

Capture and handling

We attempted to locate wolves in as many packs as possible. Wolves were captured with modified leghold traps in summer ($n = 21$) and by using a net-gun from a helicopter in early winter ($n = 5$). All wolves

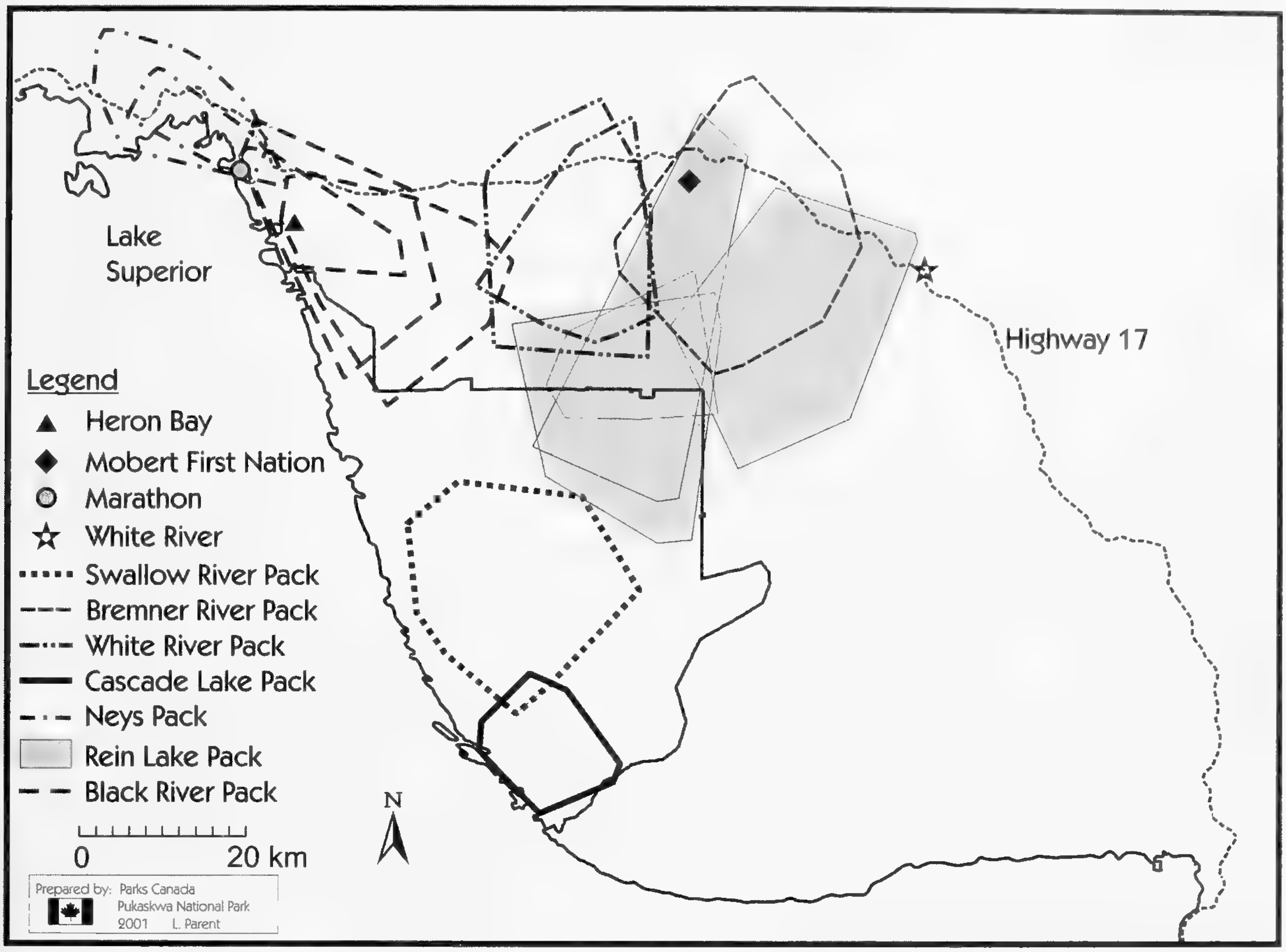

FIGURE 2. Annual (1 April – 31 March) home ranges of wolves in the study area, 1994-1998. Home ranges are 95% MCP. Years for home ranges of packs were Swallow and Bremner River Packs, 1997-1998; White River Pack, 1996-1998; Cascade Lake Pack, 1995-1996; Neys Pack, 1995-1997; Rein Lake Pack, 1994-1998; Black River Pack, 1994-1996, 1997-1998.

were immobilized with Telazol® (tiletamine hydrochloride (HCL) and zolazepam HCL, A.H. Robins Co., Richmond, Virginia). Rectal temperature, pulse, and respiration of wolves were closely monitored throughout the procedure. Immobilized wolves were examined for injuries, equipped with conventional VHF transmitters (Lotek®, Newmarket, ON), weighed, sexed, and aged. A committee for care of wild animals approved all capture and handling operations (Wildlife Animal Care Committee, Ontario Ministry of Natural Resources, 1994-1997).

Biotelemetry

The target frequency for locating each radio-collared wolf was four times/month in summer (April-October) and six to eight times/month in winter (November-March). Wolves were located by plane using a portable receiver (Lotek® SRX-400), right-left switch boxes, and paired three-element Yagi antennae mounted on the wing struts of a fixed-wing aircraft (Cessna 185). Wolf location was recorded with a Global Positioning System (Garmin® 75 Aviation). For all locations, transmitter frequency, observer, date, time of location, number of wolves, color of wolves, and presence of pups were recorded. Mean error of telemetry (difference between observed and true location) was calculated by using data we collected when regularly locating stationary transmitters placed throughout the study area. Location data were downloaded into a Geographical Information System (GIS [Tydac SPANS®]) for display and analysis of wolf movements.

Home Ranges

Ranges V® software (Kenward and Hodder 1996*) was used to calculate annual (1 April – 31 March) sizes of home ranges. To represent these areas we used relocations of packs and 95% minimum convex polygons (MCP) (Mohr 1947). All obvious extraterritorial forays and dispersals were excluded from the analyses (Ballard et al. 1997). We assumed home ranges were defined when the observation-area curve formed an asymptote (Kenward and Hodder 1996*) and locations were obtained throughout the year.

For each pack we used one radio-collared wolf/year to represent the annual home range of the pack. This is reasonable as locations from one wolf indicate position of the entire pack when a high degree of association exists among pack members (Kolenosky

and Johnston 1967; Fuller and Keith 1980; Fritts and Mech 1981; Ciucci et al. 1997). This condition was confirmed in this study by aerial observations of packs during telemetry flights.

Accuracy of locations for the entire study was 150 m, which was the mean error of telemetry obtained by all participants. Accordingly, we changed the fix resolution from the Ranges V® default of 1 m to 150 m. This resolution was used to set the width of the boundary strip that was included in polygon edges and areas (Kenward and Hodder 1996*). We left the scaling parameter at the software default of 1 m, which means that each coordinate unit was 1 m from the next.

Density, pack sizes, and population growth

Density of wolves/1000 km^2 was calculated by determining intra-pack densities (number of wolves in pack/home range size) and averaging these densities/year (Potvin 1987; Bjorge and Gunson 1989; Okarma et al. 1998). The number of wolves in a pack was based on the maximum number of wolves observed in mid-winter (15 January-15 February). We defined a pack as a group of two or more wolves that traveled together for more than one month (Messier 1984). In two cases we had insufficient data to determine the sizes of home ranges, thus we followed Messier (1985) and used data from previous or subsequent years.

Population growth or the mean annual finite rate of increase was calculated based on the ratio of successive yearly estimates of density (Fuller 1989).

Reproduction

We did not observe wolves at dens during this study. Dense vegetation and the secretive nature of wolves precluded accurate visuals of wolf groups until October or November, at which time pups were difficult to distinguish physically from adults. Hence, successful year-specific reproduction was ascertained when: (1) pups were captured in spring; or (2) a pack increased in size from March to the following December, providing that sites of focal activities (e.g., pup-resting areas) were observed in the intervening time (Messier 1985). Unsuccessful reproduction (i.e., no or failed reproduction) was ascertained when: (1) a pack did not demonstrate focal activity sites in the summer; or (2) a pair remained together from March to the following December (Messier 1985). Results are reported for each pack by year.

Moose density

To examine availability of ungulate biomass to wolves, we used Moose density (moose/1000km^2) based on aerial surveys using stratified random sampling (Gasaway et al. 1986*). More specifically, from 1993 to 1999 a single Moose density was calculated for PNP and the three Wildlife Management Units (21A, 21B, 33) surrounding PNP where wolf packs were distributed. There was little or no change in Moose density among yearly estimates (Burrows 2001), thus we averaged results from 1993-1999 for each area.

Rates of kill and consumption of prey by wolves

The rates of killing and consumption of large prey by wolves in four packs were studied by daily aerial and ground observation, January-March 1998. The Bremner River Pack was located 57 times between 18 January and 27 March 1998 (69 days) and the Rein Lake Pack was located 57 times between 8 January and 26 March 1998 (79 days). Other packs located were the White River Pack, 22 times between 11 February and 20 March 1998 (38 days) and the Swallow River Pack, 22 times between 9 February and 22 March 1998 (42 days). To calculate the kill rate, we recorded the number of animals killed by wolves/tracking period and the number of wolves present at the kill (Messier 1985). Prey killed were located from the air and from ground-based tracking. At kill sites, we confirmed prey species, time, and cause of death. For only the largest pack of wolves (Bremner River), in addition to aerial locations, we simultaneously snow-tracked wolf movements and collected scats to determine if all kill sites were found with the aerial telemetry. Technicians at Big Sky Laboratory (PO Box 0776, Florence, Montana 59833-0776) identified prey remains by macroscopic examination and comparison with known material and hair-scale impressions (Adorjan and Kolenosky 1969*).

In this analysis we considered only tracking sessions where pack locations were not separated by >54 hr. There were a few exceptions, however, where locations were separated by 72 hr. These periods were retained in the analysis because wolves made a kill or visited one of several garbage dumps the day they were relocated making it unlikely that we missed a kill. Nonetheless, kill rates in this study should be considered minimums as wolves were not relocated every day and some small prey such as deer (fawns and adults), Caribou calves, Beaver, and other smaller prey items may have been missed. It is unlikely, however, that we missed many of these kills because White-tailed Deer and Caribou were rare in the study area. We report kill rates as ungulates killed/wolf/day.

Rates of consumption were calculated based on kill rates and average weights of wolves and prey. We calculated the whole weight of wolves based on the average from radio-collared adults and other wolves found dead in the study area. The average edible weights of Moose and beaver prey were assumed to be 330, 261, 114, and 13 kg for adult male Moose, adult female Moose, young-of-the-year Moose and Beaver, respectively (Peterson 1977; Thurber and Peterson 1993). We assumed the average weight of a White-tailed Deer was 105 kg for an adult male (Kolenosky 1972; Forbes and Theberge 1996). Eighty % of the adult deer carcass was considered edible (Pimlott 1967; Forbes and Theberge 1996). All consumption rates are reported as kg prey/kg wolf/day.

TABLE 1. Sizes of annual home ranges and home range areas/wolf of seven packs of Grey Wolves (*Canis lupus*) in the study area, 1994-1998.

Year	Pack	Early winter number of wolves in pack[a]	Late winter number of wolves in pack[b]	100% MCP (km^2)[c]	95% MCP (km^2)[c]	Number of radio fixes	Area/wolf (km^2)[d]
1994-1995	Black River[e]	6	4	283	156	53	26
	Rein Lake	3	3	310	249	38	83
1995-1996	Black River[e]	4	4	548	388	55	97
	Rein Lake	3	3	600	533	58	178
	Neys[e]	3	4	269	244	96	81
	Cascade Lake[f]	1	1	204	170	26	170
1996-1997	Rein Lake[e]	2	1	561	557	39	279
	Neys[e]	6	4	113	101	96	17
	White River	2	2	407	345	37	173
1997-1998	Black River[e]	4	3	468	450	74	113
	Rein Lake[e]	2	1	692	600	87	300
	White River	2	2	589	498	65	249
	Bremner River	6	3	760	644	93	107
	Swallow River	5	3	567	500	62	100
	Mean	3.5	2.7	455	388	63	139
	SE	0.5	0.3	52	48	6.3	25

[a] Maximum pack size, 15 January-15 February.
[b] Maximum pack size, March.
[c] Sizes of home ranges were described using the minimum convex polygon method (MCP) (Mohr 1947).
[d] Based on 95% MCP.
[e] Packs that used town dumps.
[f] Home range size and home range area/wolf were not included in mean because the areas were not fully defined; i.e., the observation-area curve was asymptotic but locations were not obtained throughout the year.

Mortality and survival of radio-collared wolves

We completed survival analysis for radio-collared wolves from 20 August 1994 to 31 December 1998. Wolves were re-located from time of capture until mortality or the radio-signal disappeared. For known deaths we estimated the date of mortality to the nearest day using evidence from the field. When evidence was unavailable, day of mortality was deemed the midpoint of the interval between the last day the wolf was known alive and the day it was discovered dead. The cause of mortality was often identified on site and when possible, confirmed by necropsy.

We calculated the cumulative mortality of radio-collared wolves ($n = 25$) using the Kaplan-Meier product limit estimator and Minitab (Version 12) software. One of 26 captured wolves was shot by a trapper while in the research trap and is not included in the analysis. Cause of mortality was described using %. We assumed the proximate cause of death was the ultimate cause of death. We were unable to assess the relative importance of other factors that may have been involved.

Results

Twenty-six adult wolves were captured and then radio-collared ($n = 25$) or tagged ($n = 1$) from 1994-1997. These animals represented seven packs and one lone wolf. Two of seven packs occurred almost exclusively in the park and all wolf packs were radio-collared in the study area. There were no other wolf packs in the study area during this study. We followed two packs in 1994-1995, four in 1995-1996, four in 1996-1997, and six in 1997-1998. The average mass of adult female wolves ($n = 11$) was 26.9 ± 1.4 kg and that of adult males ($n = 14$) was 36.5 ± 2.8 kg.

Home ranges

Sizes of annual home ranges (Figure 2) of seven packs across 13 pack-years were adequately described in this study (Table 1). Estimates accurately represented areas used by wolves because sizes of annual home ranges were not correlated with number of relocations ($r_s = 0.52$, $0.05 > P > 0.02$). Home range sizes of packs and home range areas/wolf were variable. The average annual home range size was 388 ± SE 48 km^2 (95% MCP, $n = 13$, range = 101-644 km^2)

(Table 1). The average home range area/wolf was 139 ± SE 25 km^2 (95% MCP, n = 13, range = 17-300 km^2) (Table 1).

Density, pack sizes, and population growth

Wolf density did not change over time; recorded densities were 7.9, 9.6, and 7.2 wolves/1000 km^2 in 1995-1996 (n = 4 packs), 1996-1997 (n = 4), and 1997-1998 (n = 6), respectively. Density declines, however, if the Neys pack (Figure 2) is excluded from the calculations. This pack exclusively used dumps for food (Krizan 1997) and the home range was much smaller compared with all other packs in the study (Table 1). Accordingly, wolf densities were 7.1, 5.9, and 5.9 wolves/1000 km^2 in 1995-1996 (n = 3 packs), 1996-1997 (n = 3), and 1997-1998 (n = 5).

Average mid-winter (15 January – 15 February) pack size was 3.5 ± SE 0.5 wolves (n = 14 pack-years) (Table 1). This average declined in late winter (March) to 2.7 ± SE 0.3 (n = 14 pack-years). The number of wolves in all except two packs remained stable or declined, 1994-1998. Numbers fluctuated annually in the Neys and Swallow River Packs (Table 2). Accordingly, the mean annual finite rate of increase from 1995-1998 was 0.96.

Reproduction

From spring 1994 to spring 1998, wolves reproduced successfully in eight of 22 pack-years (36%) (Table 3). This was a maximum estimate of successful reproduction. In two of eight pack-years, we assumed wolves had reproduced because large numbers of wolves were noted in the packs in the following early fall and winter.

Moose density

Average densities of Moose varied among management units. Management Unit 33 had the highest Moose density (0.285 ± 0.03-0.07 moose/km^2 90% CI) followed by Unit 21A (0.225 ± 0.02-0.03), 21B (0.220 ± 0.02-0.03), and PNP (0.153 ± 0.03-0.08).

Rates of kill and consumption

The Swallow River (3 wolves) and Bremner River Packs (5) killed and consumed more ungulates than the White River (2) and Rein Lake Packs (2). The kill rates for each pack respectively were 6.8, 3.4, 0.0, and 0.0 ungulates/wolf/day. Consumption rates were 0.21, 0.11, 0.0, and 0.0 kg prey/kg wolf/day. The White River and Rein Lake Packs did not kill any ungulates; however, both packs scavenged from various sources. The White River Pack scavenged from Moose that were killed by vehicles or trains, from other wolf kills, and from snare sets. The Rein Lake Pack scavenged from refuse in the town dump for White River (Figure 2).

Mortality and survival of radio-collared wolves

As of 31 December 1998, 17 of 26 wolves radio-collared or tagged from 1994 to 1998 were dead, only four were confirmed alive, and five were missing. Eight wolves died from human causes: trains killed three, three were snared, and two shot. Nine wolves died from natural causes: two starved, two were killed by other wolves, four died from disease (three from mange and one from blastomycosis), and one died from unknown natural causes. We assumed this last wolf was not killed by humans because we were in a remote area, there were no signs of humans in the area, and we found no bullets, snares, or other human devices. Survival of radio-collared wolves decreased between one and three years post-collaring. Wolves had a 32% (SE 0.10) chance of dying in the first year, a 30% (SE 0.15) chance of dying in the second year, and a 57% (SE 0.26) chance of dying in the third year. Median survival time was 689 days or 1.9 years post-collaring.

TABLE 2. Highest numbers of wolves in packs in the study area, 1994-1998. The number of sightings is in parentheses.

	Pack size[a]				
Pack	1994	1995	1996	1997	1998
Rein Lake	3(4)	3(3)	1(2)	1[b]	0
White River	2(2)[b]	2(4)	2(2)	2(9)	2(2)
Bremner River				3(3)[b]	
Cascade River		1(4)	0		
Black River	4(2)	4(2)	4(2)	3(4)	
Swallow River			5(2)[b]	3(3)	4(1)
Neys		3(4)	4(2)	2(2)	4(2)

[a] Maximum numbers of wolves seen in March.
[b] Pack sizes were confirmed by track-counts made from the ground.

TABLE 3. Reproductive success of wolf packs, 1994-1998.

	Year				
Pack	1994	1995	1996	1997	1998
Black River	+[a]	–[a]	–	+	+
White River	+[b]	–	–	–	–
Rein Lake	+[b]	–	–	–	–
Neys			+	–	?
Bremner River				+	+
Swallow River				–	–

[a] + = reproduced successfully; – = did not reproduce successfully.
[b] This pack likely reproduced successfully because many wolves (10) were seen in late fall (November – December).

Discussion

Population limitation of wolves

The growth rate of the wolf population in the study area was limited from 1995-1998. The mean annual finite rate of increase, 0.96, indicated a 4% rate of decline. This rate of increase is not unique, however, and similar rates recorded from other populations have varied from 0.93-2.40 (Theberge and Strickland 1978; Fritts and Mech 1981; Ballard et al. 1987; Hayes et al. 1991*; Messier 1991; Pletscher et al. 1997).

In addition to the estimated rate of growth, there are a number of other factors that suggest the wolf population was declining slightly. First, pack sizes were small and generally declining. Mean pack size (3.5 wolves ± SE 0.5) was much smaller than the average of 10 wolves for packs that hunt moose in North America (Mech 1970). Furthermore, five of seven packs in this study remained stable or declined in size from 1994 to 1998. If this population were increasing in size, the number of wolves within packs would likely increase. This happened in the Yukon where rapid increases in pack sizes of colonizing wolves were the primary means by which an intensively reduced wolf population reached their pre-reduction densities (Hayes and Harestad 2000).

High cumulative mortality of wolves is the second factor that suggested a declining population. We compared the cumulative rate of mortality from the first year (32%) of our study with annual rates of mortality from other studies. There is little agreement among researchers on the annual rate of mortality that causes a population decline in wolves. However, Fuller (1989) reviewed several wolf studies across North America and concluded that populations would stabilize with an overall annual mortality rate of 35%. Given this, it appears the mortality rate in this study was sufficient to account for the slightly declining rate of growth in this study.

Coupled with high mortality of adult wolves, low reproductive success of wolves in this study suggested a population decline. Wolves reproduced successfully in only 36% of possible occasions compared with 45-93% noted in other areas (Messier 1985; Potvin 1987; Peterson et al. 1998; Hayes and Harestad 2000). We were unable to determine if wolves produced pups that died soon after birth or whether whelping occurred at all. Lack of denning, however, suggests no pups were produced.

Limiting factors

We examined the importance of two factors that limited the growth of the wolf population in this study: ungulate biomass and human-caused mortality. Ungulate biomass is commonly reported to limit growth of other wolf populations (Mech 1977a; Fuller and Keith 1980; Packard and Mech 1980; Keith 1983; Messier 1985; Peterson and Page 1988) and data from this study suggest it was important. The strongest data represented the occurrence of natural-caused mortality. In this study, more than half (9 of 17) of radio-collared wolves died from natural causes, which is high compared with other North American studies (Peterson 1977; Carbyn 1982; Peterson et al. 1984; Ballard et al. 1987; Hayes et al. 1991*). Starvation and intraspecific aggression were responsible for four of nine (24%) wolves dead in this study and have been reported common in other populations where ungulate biomass is low. For instance, in southwestern Quebec, Messier (1985) noted wolves with fewer prey available incurred more deaths from natural causes, namely starvation and intraspecific aggression. In that area, similar to our study area, moose density was 0.23 moose/km^2 and there were no other ungulate species present. Similarly, Mech (1977a) noted occurrence of starvation and intraspecific aggression increased as prey availability declined in Minnesota.

Disease was the other natural cause of death observed in this study. Four of nine wolves (24%) died from either sarcoptic mange or blastomycosis. Blastomycosis is enzootic in Minnesota (Schlosser 1980) and Wisconsin (Sarosi et al. 1979; McDonough and Kuzma 1980) but until now (Krizan 2000; Paquet et al. 2001), had not been reported from other wolf populations across North America. This level of disease-related mortality has not been reported in any other populations of wolves. In other populations, disease accounts for 2-21% of wolf mortality (Carbyn 1982; Peterson et al. 1984; Fuller 1989; Ballard et al. 1997) and is often not even reported (Messier 1985; Ballard et al. 1987; Potvin 1987; Hayes et al. 1991*; Meier et al. 1995; Pletscher et al. 1997). The only other study where disease clearly affected a wolf population was in Alaska where rabies accounted for 21% of wolf mortality and was a significant factor in the decline of the population (Ballard et al. 1997). Disease cannot be linked with certainty to low ungulate biomass but wolves that lack food should be more vulnerable to disease than those with more food available. Furthermore, food shortage leading to nutritional stress could combine with disease factors to increase the significance of otherwise innocuous or sub-lethal conditions (Brand et al. 1995).

We also examined rates of consumption of ungulate prey to determine the importance of ungulate biomass as a limiting factor. Consumption rates for three of four packs in this study were low (Bremner River, Rein Lake, and White River). These packs consumed <0.13 kg/kg wolf/day, which Mech (1977b) determined is the minimum rate of consumption required for all wolves to survive and rear pups successfully. Two packs killed no ungulates and relied on scavenging to survive (White River and Rein Lake Packs).

These data suggest that at least three of four packs could have been limited by food. Indeed, in the White River Pack, the dominant female failed to reproduce the following spring and was extremely emaciated (mass = 23.5 kg) when killed by other wolves later in the summer. Similarly, the Rein Lake Pack was reduced to one wolf by winter 1997. She did not reproduce the following summer and to survive, she scavenged mainly from the town dump for White River (Figure 2). She was dead as a result of mange by December 1998 (mass = 28.5 kg). The Bremner River Pack may have been limited by food but data were not strong. One wolf dispersed in summer 1998 and died from unknown natural causes. Other wolves could have dis-

persed and died later because pack numbers dropped from nine to three over the winter 1997-1998 (unpublished data). Some members of this pack, however, did survive and reproduce two years in a row.

Most of the rates of consumption in this study are similar to those from other areas where starvation and other signs of malnutrition of wolves were noted. For instance, Messier (1987) noted more deaths of wolves from malnutrition in areas of low density of moose (0.23 moose/km^2) where wolves had 0.05 kg/kg wolf/day (based on kill rate of 1.7 kg/wolf/day and wolf mass of 32.3 kg). Peterson and Page (1988) noted starvation and other indicators of severe nutritional stress in an area of high Moose density (1.9 moose/km^2) when food availability fell below 0.12 kg/kg wolf/day (based on kill rate of 4.0 kg/wolf/day and wolf mass of 32.3 kg).

As a final method to assess the importance of ungulate biomass, we examined density of Moose, the main prey for wolves in this study. Moose density was low to moderate (0.153-0.285 moose/km^2) and similar to Moose densities in other areas where wolves were nutritionally stressed. Messier (1987) found that in areas where Moose density dropped below 0.4 moose/km^2, wolves were nutritionally stressed. He also reported that below 0.2 moose/km^2 wolf packs could not subsist and (or) reproduce successfully (Messier 1985).

The second limiting factor we examined was human-caused mortality. Besides ungulate biomass, it is the other most commonly reported factor that limits the growth of wolf populations (Gasaway et al. 1983; Keith 1983; Peterson et al. 1984; Fuller 1989; Noss et al. 1996; Paquet et al. 1996*). In other areas where human-caused mortality was considered the primary limiting factor, it accounted for 69-80% of all mortality (Peterson et al. 1984; Ballard et al. 1987, 1997). In our study area, human causes accounted for only 47% of mortality of adult radio-collared wolves. Nonetheless, human-caused mortality is likely still important, particularly given the low ungulate biomass and reproduction noted in this study. Gasaway et al. (1983) found that in areas with low ungulate biomass, harvest levels as low as 20% can limit wolf populations. Fuller (1989) found that wolf populations with low productivity can withstand less overall mortality because there are fewer pups, which often make up disproportionate amounts of harvests.

In conclusion, the population growth of wolves in this study area was limited and declined slightly based on (i) mean annual finite rate of increase; (ii) small and generally declining pack sizes; (iii) high cumulative mortality; and (iv) low reproductive success.

Based on these demographic patterns, low availability of ungulate biomass and existing levels of human-caused mortality, this population likely will remain at present low densities or continue to decline. This situation is challenging to managers for Parks Canada Agency because the study area, which includes a National Park, may not have a highly productive source population for wolves. Further, protection for wolves outside the park is limited because few restrictions exist regarding the nature, timing, and extent of wolf harvesting.

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Estimation of Seed Bank and Seed Viability of the Gulf of Saint Lawrence Aster, *Symphyotrichum laurentianum*, (Fernald) Nesom

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The Gulf of St. Lawrence Aster, *Symphyotrichum laurentianum*, is a member of the family Asteraceae and is listed as "threatened" by COSEWIC (Committee on the Status of Endangered Wildlife in Canada). This rare and vulnerable halophyte grows in only a few locations in New Brunswick, Prince Edward Island, and the Magdalen Islands, Quebec. As an annual, *S. laurentianum* relies exclusively on its seeds to survive to the next generation. The goal of this study was to estimate the quantity of viable *S. laurentianum* seeds in the persistent and transient seed banks at selected sites in Prince Edward Island. Overall, the number of seeds in the transient and persistent seed banks is low. The greatest concentration of seeds was found near the surface of the soil. In addition, only a small proportion of those seeds tested positive for viability based on Tetrazolium staining. Of the seeds in the persistent and transient seed banks combined, 53% were viable whereas only 2% of the seeds in the persistent seed bank were viable. Population surveys were also completed at the five known sites (both extinct and extant) in Prince Edward Island National Park. All sites showed signs of decline based on population estimates dating back to 1993. The Covehead Pond site showed the greatest decline: from 250-300 individuals in 1993 to only 10 individuals in 2002. The population at Dune Slack also showed a dramatic decrease from approximately 65 000 in 1999, to 2 200 individuals in 2002. Monitoring of this plant and the development of a management plan for the species are critical to its survival.

Key Words: *Symphyotrichum laurentianum*, *Aster laurentianus*, Gulf of St. Lawrence Aster, seed viability, Tetrazolium, transient and persistent seed banks, rare plant, COSEWIC, Prince Edward Island National Park.

The Gulf of St. Lawrence Aster, *Symphyotrichum laurentianum* (Fernald) Nesom, is a member of the family Asteraceae and is listed as "threatened" according to COSEWIC (Committee on the Status of Endangered Wildlife in Canada 2004*). It is an annual plant that relies exclusively on its seeds to survive until the next germination season, which makes this plant very vulnerable. *S. laurentianum* is a rare halophyte only found in a few areas in Prince Edward Island (PEI), New Brunswick (NB), and the Magdalen Islands in Quebec. It grows in salt marshes that are only flooded during spring and high tides. The St. Lawrence Aster has smooth, hairless, and fleshy linear-lanceolate to spatulate, generally sessile leaves (Figure 1). It can grow up to 30 cm tall and can bear 1 to over 700 flower heads (Houle and Haber 1990). Each flower head is subtended by leafy bracts and is composed exclusively of white to pink disk florets surrounded by a white pappus (Stewart 2000* and Figure 1). Seeds are enclosed in achene fruit walls when they are dispersed.

In 1990 fewer than 1000 plants were known to exist in PEI, NB and Quebec (Magdalen Islands) combined. However, further research and surveys have produced several new sites. While several sites in PEI and Quebec contain more than 1000 individuals each, the St. Lawrence Aster is still vulnerable to extinction (Gilbert et al. 1999*; Stewart and Lacroix 2001). Recent research conducted by Stewart (2000*) showed that population sizes could suddenly decline dramatically.

The extent of the persistent seed bank of a plant must be known in order to fully understand the germination ecology of the species (Baskin and Baskin 1998). In addition, the viability of a plant's seeds must also be maintained in order for the plant to be successful (Fenner 2000). A seed bank is a reserve of viable, ungerminated seeds in the soil. Seeds are considered viable if they have the ability/potential to germinate under favourable conditions (Baskin and Baskin 1998). There are two categories of seed banks: transient and persistent. A transient seed bank refers to a short-term storage of seeds, that is seeds that are viable for one year or one germination season. The seeds in the transient seed bank therefore germinate in the first year after dispersal. Any seeds that are dormant and survive to subsequent germination seasons are considered to be part of the persistent seed bank. The persistent seed bank contains seeds that remain viable in the soil for at least two germination seasons, making this a long-term reserve of seeds that are at least one year (or one germination season) old. A knowledge of both the extent of the seed banks and the germination potential of seeds of *S. laurentianum* constitutes crucial baseline data to develop a management plan for the species.

The specific goals of this study were: (1) to estimate the quantity of seeds in the seed bank (both transient and persistent) for *S. laurentianum* at each of the selected sites in PEI in order to evaluate the ability of the plant to maintain current populations, and (2) to test the

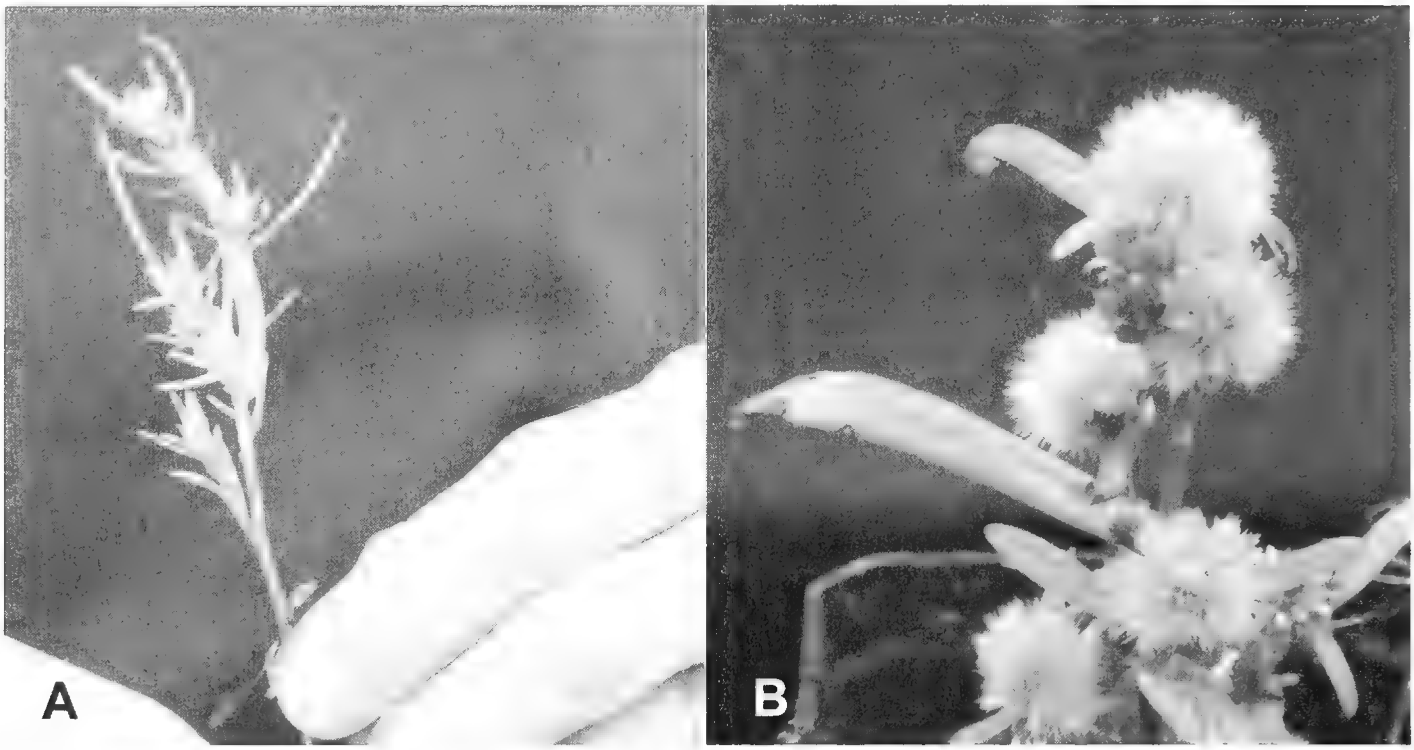

FIGURE 1. Representative photographs of *Symphyotrichum laurentianum*, pre-flowering (A) and post-flowering (B).

viability of seeds in the persistent seed bank and the transient seed bank.

Materials and Methods

Population Surveys

Five sites within the PEI National Park (Figure 2) were visited. Total population counts were made at the Covehead Pond and East Marsh A sites because of the small number of plants at these locations. The Western Wetland site was also surveyed to confirm that no asters were growing there. Population estimates were recorded for Dune Slack and East Marsh B sites because of the large population sizes. These estimates were accomplished by using a grid system. The general area where the plants were growing was subdivided into 0.5 m^2 sections. A random number of sections was selected and all plants within these grids were counted. These counts along with the total area of the site were used to extrapolate the approximate number of plants found at each site.

Collection of Soil Samples

Soil cores were taken from five sites within PEI National Park (Figure 2), the only location in the province where the plant is found: Covehead Pond, Dune Slack, East Marsh A, East Marsh B and Western Wetland. Three transects were run at each site except Covehead Pond. Twenty coring points were flagged along three transects in Dune Slack. Due to sampling limitations imposed by Parks Canada, only ten coring points were flagged along three transects at East Marsh A and a further ten along the three transects at East Marsh B. Similarly, ten coring points were also flagged along the three transects for Western Wetland. Eleven coring points were flagged at Covehead Pond in a slightly different manner because of the physical nature of the site. Four transects were run from the water's edge of the pond to the high tide mark along the traditionally heavily populated side of the pond. Eight coring points were flagged evenly among these transects and the remaining three points were spaced evenly along the other side of the pond where the plants were also reported to grow.

Two sets of soil cores were taken from each site: one during late June/early July, and another during late August/early September. These dates were chosen to correspond to the type of seed bank that was sampled. The late June/early July samples were taken before the emergence of the 2002 season plants, to ensure that the transient as well as persistent seed banks were included. The late August/early September samples were taken after all the seeds that were going to germinate that season had germinated. Consequently, only the persistent seed bank was included in this specific sample date.

All the core samples were taken using an Oakfield "LS" 36" soil sampler with an effective coring length of 24 cm and an inner diameter of 1 inch. In order to study the vertical distribution of seeds in the soil, each soil core was divided equally into a top, middle, and bottom section. Each section of the core was labelled, placed into a separate bag, and put in a freezer set at -4°C until processing which took place two weeks to three months later. All seeds found in the soil samples were tested for viability.

Viability Testing

Seeds were tested for viability using 2,3,5-triphenyl tetrazolium chloride (TTC) (Grabe 1970). The TTC test is based on a colour reaction: any seeds that are

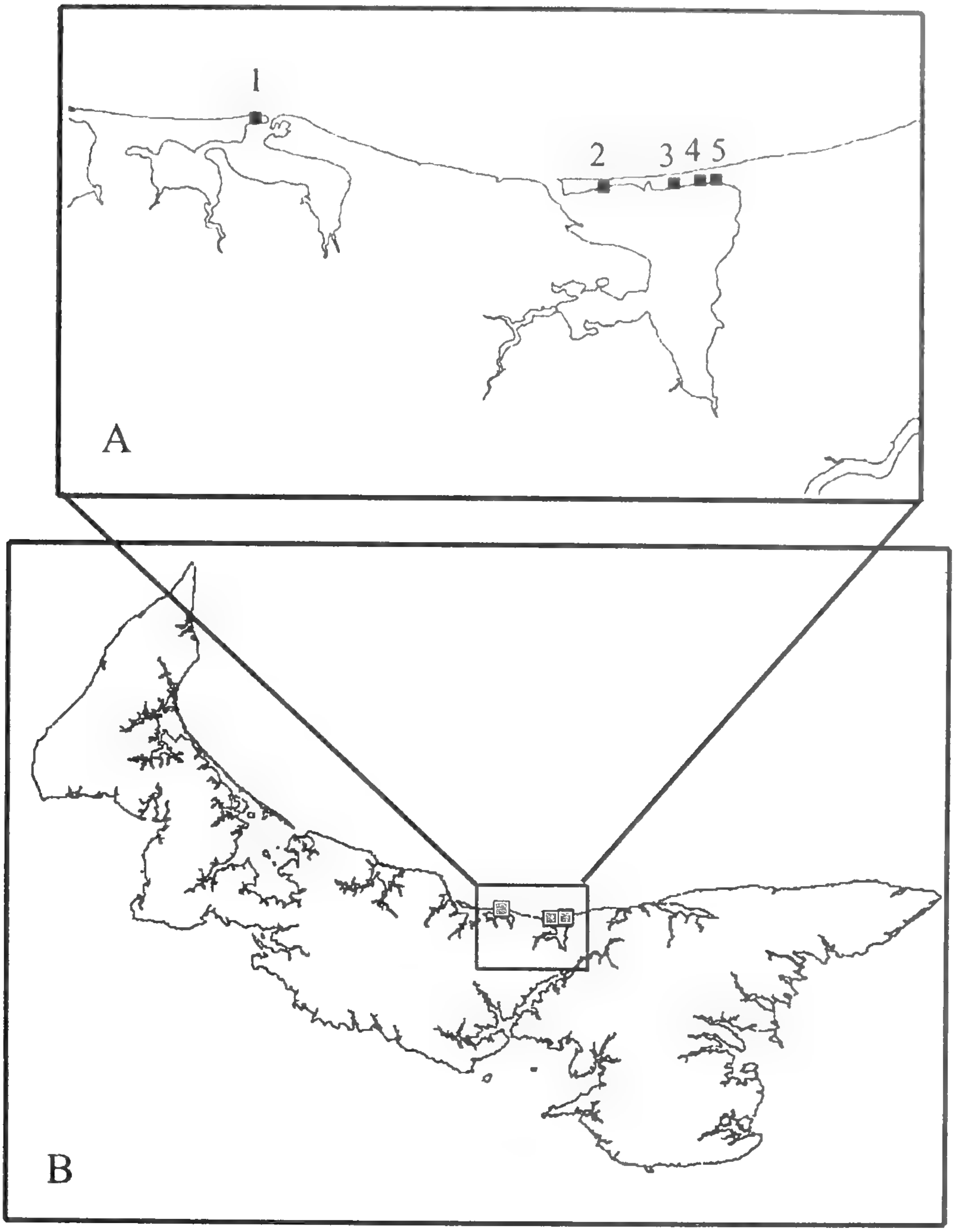

FIGURE 2. Map of all Prince Edward Island sites used in this study. Study sites are depicted as squares on both maps. All five sites shown in (A) are located in the national park: 1. Covehead Pond, 2. Western Wetland, 3. Dune Slack, 4. East Marsh B, and 5. East Marsh A. (B) Location of sites on Prince Edward Island with black square highlighting the specific area shown in (A).

viable will stain pink/red. Complete achenes (containing seeds) were placed on a piece of filter paper in a petrie dish, and left overnight to soak in distilled water. The next day, when the seeds were fully imbibed with water, they were dissected out of the achene fruit wall and seed coat. After removal of the seed coat, the embryos were placed in a 1% TTC solution for two hours at 35°C, as prescribed for dicotyledonous seeds. The embryos were then evaluated for viability according to the scheme developed in Grabe (1970). As a general rule, the radicle, shoot tip and cotyledons must stain pink/red in order for the seed to be considered viable.

Statistical Analysis

The viability of seeds in the soil was compared graphically for vertical distribution and sampling dates. Statistical analysis was not possible on these data because there was no replication. Due to the vulnerable status of the plant, sampling was limited by restrictions on collecting imposed by Parks Canada. The vertical distribution of seeds and fruit walls within the soil was compared using Kruskal-Wallis tests (non parametric equivalent of ANOVA). All data from the five sampling sites on PEI were pooled for analysis.

Results

Population Sizes

Population sizes for all known PEI sites are shown in Table 1. All populations experienced a decrease in numbers, the most noticeable of these being the population at the Dune Slack site with more than 95% decline. The smallest population at the Covehead Pond site also experienced a decrease from 243 individuals in 1999 to only 10 individuals in 2002.

Seed Banks

A total of 122 cores were taken from PEI sites. Of these, 32 contained at least one seed. There were significantly more seeds in the top portion of those cores than in any other portion of the soil samples (Figure 3; Kruskal-Wallis test; $P < 0.05$, n=45 for each portion). The non-random distribution of the seeds, as evidenced by the highly variable number of seeds found in the core samples, is also highlighted in Figure 3. This may be related to where the plants clustered the year before, a factor we were not able to determine prior to establishing coring sites.

Seed Viability

There was a noticeable decline in the percentage of viable seeds among the top, middle, and bottom sections of the soil cores taken on PEI. We found that 28.4% of the seeds in the top section of the cores were viable compared to 20% of the seeds in the middle section of the cores. None of the seeds in the bottom section of the cores were viable.

There was a marked decline in the percentage of viable seeds between the late June/early July sample and the late August/early September sample (Figure 4). The percentage of viable seeds in the persistent seed bank (2%) is practically non-existent when compared to the viability of the seeds in the persistent and transient seed banks combined (53%). This means that the majority of viable seeds germinate within one year of being produced.

Discussion

Population Sizes

Symphyotrichum laurentianum populations on PEI continue to show dramatic fluctuations and it can be very difficult for an annual plant to rebound from these declines in population size. Although the Dune Slack site was considered one of the two largest populations on PEI; its rate of decline, if maintained, will bring the population down to a size comparable to the smallest populations. A comparatively small population at Covehead Pond has been relatively stable at 150 to 300 individuals for the past ten years but the last population count found only ten individuals which, coupled with the low viability of seeds in the seed banks, indicates that this site is on the verge of extinction if preventive measures are not taken.

The Island Nature Trust, a local conservation organization, conducted a survey of suitable areas on PEI in 2002 to locate new populations of *S. laurentianum*. Several prime candidate habitats were located but unfortunately no asters were found at those sites (MacQuarrie, personal communication).

Seed Banks

There appears to be a lack of mixing of the soil in the salt marshes which causes a clustering of seeds in the top sections of the soil. This trend is obvious in the vertical distribution of seeds shown in Figure 3. Seeds that remain trapped in the upper layer of the soil are more likely to get exposed to the elements thereby potentially affecting the viability of the embryo.

One of the most meaningful results from this study is the fact that the viability of seeds in the persistent seed bank is practically non-existent. This can be devastating for an annual plant such as *S. laurentianum*. Without the long-term storage of viable seeds, this plant is vulnerable to short term changes in its habitat, both natural and anthropogenic.

TABLE 1. Comparison of population sizes for *Symphyotrichum laurentianum* on Prince Edward Island.

Population	GPS Location	1992	1999	2002
Covehead Pond	46° 25' 49.39" N 63° 09' 07.98" W	168	243	10
Western Wetland	46° 24' 47.88" N 63° 01' 16.89" W	425	0	0
Dune Slack	46° 24' 51.49" N 62° 59' 41.98" W	15 000 – 20 000*	65 250*	2 200*
East Marsh A	46° 24' 55.97" N 62° 58' 43.89" W	50 000 – 60 000* (Sites A and B combined)	25 000 – 60 000* (Sites A and B combined)	133
East Marsh B	46° 24' 55.27" N 62° 59' 06.11" W			44 100*

* estimate

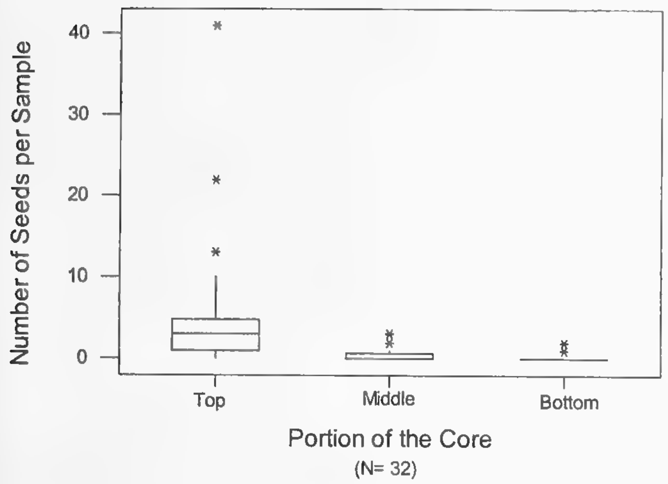

FIGURE 3. Box plots showing median (centre line) and 25th and 75th percentile for numbers of seeds found in cores from all Prince Edward Island soil samples that contained seeds. Outliers (*) are included to show the non-random distribution of the seeds.

During the summer of 2002, the Dune Slack site was heavily flooded during a storm. This caused the site, and consequently the maturing aster plants, to be smothered in eel grass. Since the Dune Slack population had already experienced a dramatic decrease in size between 1999 and 2002, the necessary number of mature viable seeds needed to survive this natural short-term event may not be available.

Covehead Pond is an example of a site that is very likely to become extinct due to anthropogenic causes. This site is isolated from Covehead Bay by a road. The culvert that is presently in place did not allow proper drainage from the pond during the summer of 2002 and caused this site to be flooded. The ten plants that were seen at this site in 2002 were flooded by water and also smothered by eel grass. This occurred at a crucial time during seed maturation. Only one plant was found at the Covehead site in 2003.

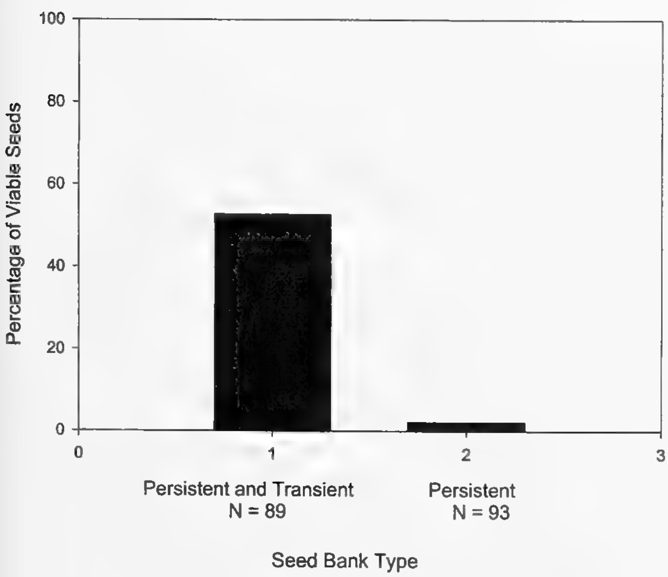

FIGURE 4. The percentage of viable seeds in the seed banks on Prince Edward Island. Persistent and transient seed banks = all late June/early July samples on Prince Edward Island. Persistent seed bank = all late August/early September samples on Prince Edward Island.

Status of the Species

In 2003, there were 441 Canadian species at risk, and 140 of these were plants (Committee on the Status of Endangered Wildlife in Canada 2004*). Until recently, there has been very little in terms of Federal legislation in place to protect these species. The Species at Risk Act (SARA) which came into effect in 2002 will hopefully facilitate this process especially with regard to developing a plan for the recovery of every extirpated, endangered, or threatened species.

The results of this study show a disturbing trend: the estimated number of seeds in the seed banks is low, the viability of the seeds in those seed banks is also low (especially in the persistent seed bank), and the populations are declining. The Gulf of St. Lawrence Aster is currently under review and it is important that all available information on the biology of the species be considered (especially information pertaining to seed banks). The status of this plant has recently been updated to "threatened" which is defined as "a species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction" (Committee on the Status of Endangered Wildlife in Canada 2004*). This new designation confirms the urgent need to design a management plan for *S. laurentianum* to ensure that it does not become extinct. Although harsh weather patterns leading to strong winds and flooding cannot be prevented (i.e., extreme flooding of the Dune Slack site during summer of 2002), alternate measures such as transplanting *ex situ* plants into affected sites should be considered. Preliminary results show that seedlings of *S. laurentianum* can be grown from seed and transplanted from culture medium to soil with a relatively high success rate (Stewart 2000*). However, a population decline and loss of suitable habitat due to anthropogenic activities can be prevented and further steps, such as ensuring proper drainage at a site such as Covehead Pond, should be taken.

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Consumption of Shrews, *Sorex* spp., by Arctic Grayling, *Thymallus arcticus*

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Moore, Jonathan W., and G. J. Kenagy. 2004. Consumption of shrews, *Sorex* spp., by Arctic Grayling, *Thymallus arcticus*. Canadian Field-Naturalist 118(1): 111-114.

In an investigation of the dietary habits of Arctic Grayling (*Thymallus arcticus*) we found that two individuals out of 93 sampled in southwestern Alaska (approximately 59°N, 159°W) contained a total of five shrews (*Sorex* spp.). These shrews contained enriched levels of nitrogen stable isotopes, suggesting utilization of nutrients derived from salmon. We hypothesize that normally terrestrial shrews accidentally enter streams while foraging along the productive riparian zones of creeks with high densities of salmon. Shrews are apparently susceptible to opportunistic predation by resident stream fishes, including Arctic Grayling, when they enter the streams.

Key Words: Arctic Grayling, *Thymallus arcticus*, diet, salmon-derived nutrients, shrews, *Sorex* spp., stable isotopes.

The Arctic Grayling (*Thymallus arcticus*) is a common nearctic freshwater fish in lakes and streams at high latitudes (Nelson 1994). Grayling typically feed on a variety of aquatic and terrestrial invertebrates in the water column or air-water interface (Armstrong 1986). In addition, Arctic Grayling occasionally supplement their diets with salmon eggs and small fish (Armstrong 1986). Despite existing knowledge of Arctic Grayling biology and its regional importance, the ecology and behavior of this species remain not well understood, including the extent to which Arctic Grayling exploit terrestrial sources of prey (Armstrong 1986).

As part of an extensive study of the aquatic and associated terrestrial ecosystem and its relationship to salmon in southwestern Alaska (Schindler et al. 2003), we had the opportunity to investigate dietary habits of Arctic Grayling. We discovered evidence of apparently rare consumption by Arctic Grayling of small terrestrial mammals of the Order Insectivora, shrews of the genus *Sorex*.

During summer 2001 we sampled resident fishes in five streams that flow into Lake Nerka in the Wood River-Tichick State Park, Dillingham County, southwestern Alaska (approximately 59°36'N, 159°05'W), by conventional and fly angling. The study streams support large runs of Sockeye Salmon (*Oncorhynchus nerka*). Captured fish were anesthetized, marked with subcutaneous tags, weighed, measured, and released. We obtained diet samples by back-flushing the stomach with a gastric lavage. Diet samples were preserved in ethanol and transported back to the University of Washington for analysis.

We sampled the stomach contents of 93 Arctic Grayling from five tributaries of Lake Nerka. Two of the 93 Arctic 2001 Grayling contained visible evidence of the body parts of shrews (Figure 1, Table 1). One Arctic Grayling (length 394 mm, mass 591 g), captured on 13 August in the Little Togiak River contained the remains of three shrews. A second Arctic Grayling (length 391 mm, mass 522 g), captured on 25 August in Elva Creek contained the remains of two shrews. Nothing else about the two observed Arctic Grayling was unusual other than their stomach contents. Although the fish were relatively large, they were not extreme, being longer than about 70% of the other Arctic Grayling. In addition to the shrews, the diets of these two fish contained aquatic and terrestrial insects typical of the diets of the other Arctic Grayling sampled at this same time and location.

The five alcohol-preserved shrews (*Sorex* spp.) from the diet samples of two Arctic Grayling were deposited in the Burke Museum mammal collection. Three shrews (UWBM 74151, 74152, 74154) were sufficiently intact that we could examine individual teeth in the skull, which is critical for species identification. We used the keys of Nagorsen (1996), based on body and skull measurements and dental characteristics, particularly the relative length of the third unicuspid. In two cases, digestion had progressed too far to allow species determination by these characters. We subsequently referred tissue samples of all five specimens to Eric Waltari, Idaho State University, for molecular (cytochrome-*b*) identification, according to protocols used in his systematic investigation of *Sorex*, as developed by Demboski and Cook (2001). Molecular identification confirmed the three initial morphological identifications and provided definitive identification for the two previously unidentifiable individuals (UWBM 74153, 74155)

The two shrews from Elva Creek were identified as *Sorex monticolus* and *Sorex cinereus* (Figure 1, upper). The *S. cinereus* specimen had a wet weight of 3.3 g

and was fairly intact except for digestion of the fur away from the skin. Due to more extensive digestion, the *S. monticolus* specimen could not be measured and weighed accurately, but its intact skull and dentition allowed a positive identification (Table 1).

The three shrews from the Little Togiak River (Figure 1, lower) included a highly intact *S. cinereus* with considerable fur still attached to its skin (Figure 1, lower, center). The other two shrews were extensively digested and could only be identified by molecular analysis, as *S. cinereus* (left) and *S. monticolus* (right). In summary, the two Arctic Graylings from two different streams both had fed on shrews of two species (Table 1).

The presence of the shrews *Sorex monticolus* and *Sorex cinereus* in this region of southwest Alaska lying to the north of Bristol Bay and east of the Kilbuck Mountains is consistent with the known geographic ranges of shrews (Hall 1981) and a more recent distributional analysis (S. O. MacDonald and J. A. Cook, personal communication). Shrew abundance and diversity are high in this area, and three other species are also present: *S. hoyi*, *S. tundrensis*, and *S. yukonicus*.

Although some species of the genus *Sorex* live and feed primarily in water (Beneski and Stinson 1987), none of the five *Sorex* species in the study area is primarily aquatic. However, all five occur to some extent in riparian habitat, where their success is enhanced by the aquatic component of the food chain. As a result of this habitat association, the shrews are potentially accessible to predatory fishes in these waters. The tendency for shrews of the genus *Sorex* to enter water, whether for foraging or dispersal, has been reviewed by Hanski (1986). In addition to intentional entry into the water, it is also possible that these shrews occasionally enter the water accidentally, resulting from their normal activities near the water's edge.

Shrews may be attracted to the riparian zones of these creeks because of the potential foraging opportunities offered by abundant salmon carcasses. Cederholm et al. (1999) list shrews, including *Sorex cinereus*, as known scavengers of salmon carcasses. Evidence from stable isotopes (^{15}N) from our study (Table 1) and Ben-David et al. (1998) show that shrews (*Sorex* spp.) living near streams containing anadromous salmon runs bear the enriched isotopic signature of feeding directly or indirectly on salmon, for example, on insects that feed on salmon carcasses. We analyzed the stable isotope signature of muscle tissue from each shrew. Because anadromous salmon have a relatively high isotopic signature ($\delta^{15}N$ = 11-13) compared to most other potential food sources, isotopes have been used to trace salmon nutrients through both aquatic and terrestrial food webs (Kline et al. 1990; Ben-David et al. 1998). The abundance of ^{15}N in shrew muscle tissue was measured by combusting several mg of ground muscle tissue from each shrew in a mass spectrometer by the Stable Isotope Lab at the University of California, Davis. Stable isotopes were expressed as a delta (δ) value—the deviation from an isotope standard (atmospheric nitrogen). In other words,

$$\delta^{15}N = [(^{15}N_{sample}/^{14}N_{sample})/(^{15}N_{atmosphere}/^{14}N_{atmosphere}) - 1] \times 1000.$$

We used a two-sample t-test to compare $\delta^{15}N$ of shrews in diets of Arctic Grayling to published values of isotopes from six shrews that were collected more than 500 m from streams with salmon in southeastern Alaska by Ben-David et al. (1998). The five shrews we collected from Arctic Grayling diets were relatively enriched, averaging 5.88 ± 0.47 $\delta^{15}N$ (mean ± standard error; Table 1), higher than shrews collected from sites over 500 m from Alaskan salmon-bearing streams, that averaged 4.5 ± 0.3 $\delta^{15}N$ ($t_{2,9}$ = 2.24, $P < 0.10$) (Ben-David et al. 1998). This relative enrichment suggests that the shrews we found in the Arctic Grayling diets may have been feeding directly on salmon carcasses or indirectly, for example, by feeding on insects that had been feeding on salmon carcasses. The high productivity of these riparian zones, especially along streams with high densities of salmon, probably contributes positively to the success and survival of shrews, the tiniest of mammals, in this extreme northern environment.

The skewed distribution of the number of shrews contained per Arctic Grayling is evidence that consumption of shrews is not a random event. We assessed whether Arctic Grayling consumption of shrews was random by comparing the observed frequency distribution of the number of shrews in Arctic Grayling stomachs to the expected distribution, assuming predation to be random. We calculated expected frequen-

TABLE 1. Characteristics of shrews removed from the stomachs of two Arctic Grayling.

Sorex spp.	$\delta^{15}N$[1]	Location	Body dimensions[2]	Specimen number
S. cinereus[3]	4.73	Elva Creek	96-38-11 mm	UWBM 74151
S. monticolus[3]	5.21	Elva Creek	indeterminable	UWBM 74152
S. monticolus[4]	6.33	Little Togiak River	indeterminable	UWBM 74153
S. cinereus[3]	7.42	Little Togiak River	88-38-12 mm	UWBM 74154
S. cinereus[4]	5.70	Little Togiak River	indeterminable	UWBM 74155

[1] $\delta^{15}N$ is the stable isotope of nitrogen and can be used to trace salmon-derived nutrients.
[2] Dimensions are total length, tail length, and hind foot length, in mm.
[3] Identified both by dentition and cytochrome-*b* analyses.
[4] Identified by only cytochrome-*b* analysis because of missing/digested dentition.

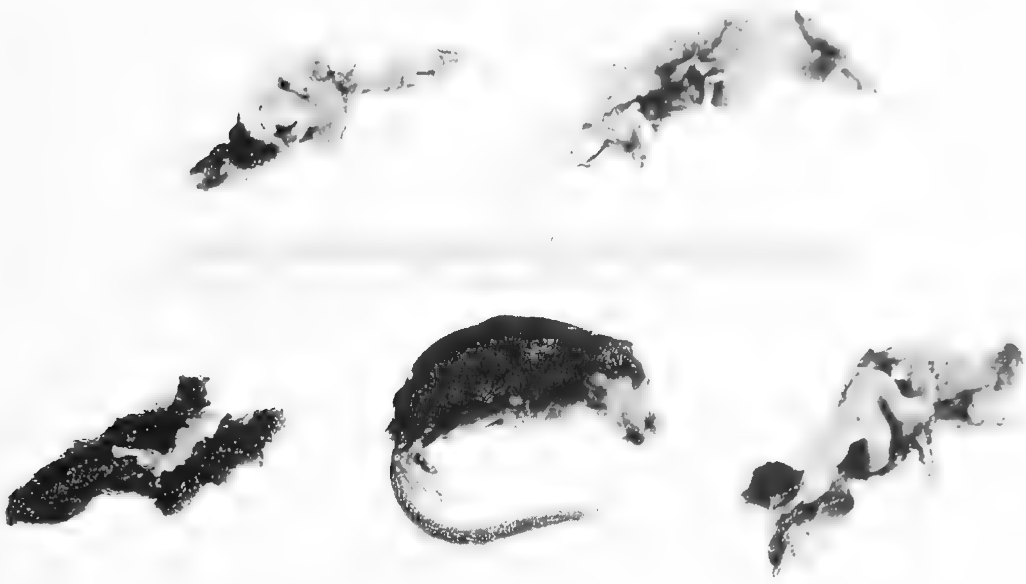

FIGURE 1. Shrews removed from the stomachs of two Arctic Grayling, in various stages of digestion. *Upper*: Shrews from a 522 g Arctic Grayling sampled at Elva Creek (59°34'N, 159°05'W) — *Sorex monticolus* (UWBM 74152) left and *Sorex cinereus* (UWBM 74151) right. *Lower*: Shrews from a 591 g Arctic Grayling at Little Togiak River (59°36'N, 159°04'W) — *Sorex cinereus* (UWBM 74155) left, *S. cinereus* (UWBM 74154) center, and *Sorex monticolus* (UWBM 74153) right.

cy distributions using the Poisson function in Matlab 5.313, assuming an average number of shrews per Arctic Grayling of 0.054 (5 shrews in 93 Arctic Grayling). We encountered fish with either two or three shrews in their stomachs, but no fish with only one shrew. Based on a random expectation for Arctic Grayling consumption, there was a 0.12 probability of sampling an Arctic Grayling with two shrews and only a 0.003 probability for three shrews. Thus we conclude that Arctic Grayling consumption is not random, and we speculate that this is due to individual differences in either the effectiveness or motivation of individual Arctic Grayling as shrew predators or scavengers. It may also be due to differences in the probability of shrews entering the feeding sites of specific Arctic Grayling.

Although Arctic Grayling are typically considered to be specialists on aquatic and terrestrial insects (Armstrong 1986), our observation indicates that some Arctic Grayling are opportunistic feeders, capable of consuming small mammals. Shrews, typically 4 – 8 g (Nagorsen 1996), represent a meal for Arctic Graylings that provides a large amount of energy compared to that of typical individual invertebrate food items. Consumption by Arctic Grayling of small mammals, including shrews, has been reported by several previous authors. Alt (1978*) reported an unspecified small number of shrews in diets of Arctic Grayling in the Fox River of western Alaska. De Bruyn and McCart (1974*) found that seven out of 136 Arctic Grayling contained a single shrew in the Firth River, Yukon, Canada. A European study of the grayling *Thymallus thymallus* indicated a 10% incidence of small mammals in the diet, particularly the shrew *Sorex araneus*, and the capture of these fish at night by bait angling suggested their ability as nocturnal hunters of semi-aquatic prey such as shrews (Teplov 1943). Miller (1946) reported that one out of 102 Arctic Grayling at Great Bear Lake, Canada, contained juvenile lemmings (rodent) of an unspecified species in the diet. Reed (1964*) also found juvenile lemmings in two Arctic Grayling out of 1300 individuals sampled in the Tanana River drainage, Alaska.

Terrestrial food sources often subsidize the diets of freshwater fish, and these food sources can include small mammals (for example, Brown Trout [*Salmo trutta*], Cochran and Cochran 1999; and Largemouth Bass [*Micropterus salmoides*], Hodgson and Kinsella 1995). Although Arctic Grayling are traditionally considered insectivores, our report demonstrates that they also opportunistically consume shrews that venture into freshwaters.

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Unusual Behavior by Bison, *Bison bison,* Toward Elk, *Cervus elaphus,* and Wolves, *Canis lupus*

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Incidents are described of Bison (*Bison bison*) in Yellowstone National Park mauling and possibly killing a young Elk (*Cervus elaphus*) calf, chasing wolves (*Canis lupus*) off Elk they had just killed or were killing, and keeping the wolves away for extended periods. During one of the latter cases, the Bison knocked a wolf-wounded Elk down. Bison were also seen approaching wolves that were resting and sleeping, rousting them, following them to new resting places and repeating this behavior. These behaviors might represent some type of generalized hyper-defensiveness that functions as an anti-predator strategy.

Key Words: Bison, *Bison bison,* Wolf, *Canis lupus*, Elk, *Cervus elaphus*, Yellowstone National Park.

Bison (*Bison bison*) are known to be aggressive to other ungulates including Elk and even to kill Elk (*Cervus elaphus*) calves (Chapman 1937: 148; Rush 1942: 225; McHugh 1958: 143; Mahan 1977). Little is known about the causes and circumstances of this aggressiveness except for the scattered reports documenting it. Bison also defend themselves aggressively when attacked by Wolves (*Canis lupus*) (Carbyn and Trottier 1988; Carbyn et al. 1993; MacNulty 2002), although Bison have been reported to be indifferent to close, but non-attacking, Wolves (Catlin 1876-1: 254 cited by McHugh 1938; Goodwin 1939: 369 cited by McHugh 1938; and Soper 1941: 403; Carbyn et al. 1993).

We also have observed the same types of behavior of Bison toward wolves both when being attacked and not being attacked in Yellowstone National Park. However, we have observed other types of Bison aggressiveness toward Elk and toward Wolves that has not been reported, and we have seen another possible case of Bison killing an Elk calf. Because our observations considerably extend what is known about Bison aggressiveness and because observation of any ungulates chasing predators are rare (Berger 1979), we report them below and propose an explanation for the possible adaptiveness of the aggressiveness.

Both Elk and Bison have inhabited the park for many decades, but Wolves were reintroduced to the ecosystem in 1995 and 1996 (Bangs et al. 1998). Wolves in Yellowstone prey primarily on Elk (Mech et al. 2001) but do kill Bison as well (Smith et al. 2000). RM made the observations in the northeastern part of Yellowstone National Park through binoculars and spotting scopes with 60× power and recorded them by tape recorder; LDM independently observed and recorded with pad and pencil the observation on 20 March 2002. DWS directed the capturing and radio-tagging of the Wolves, allowing them to be located and observed.

Observations

1. 30 May 1995 – Bison Attack Elk Calf

A recently born Elk calf that separated from its mother became mixed up in the middle of a Bison herd southwest of the Lamar Picnic Area. During the early stages of this observation, filmmaker Ray Paunovich saw a Bison knock the calf down and then repeatedly butt it to the ground.

RM watched a group of Bison encircle the calf, then lick and sniff it. The calf got up and tried to walk off, but several Bison chased it. One Bison butted the calf in the side and knocked it down. Twelve additional Bison came over to sniff it. The calf got up and ran off, but was chased and knocked down again by the Bison.

As long as the calf remained down or stood still, the Bison just sniffed and licked it, but whenever it ran off, they chased it and knocked it down. This sequence took place at least four times. A cow Bison later butted the Elk calf several times as it lay on the ground. Then the herd walked away. The calf was motionless as the Bison moved off and was possibly dead from all the butting. RM then left, but Paunovich thought he saw some movement from the calf after RM left. Whether the calf survived is unknown.

2. 6 June 2001 – Bison Displace Wolves from Kill

At 0529 hrs, RM spotted a fresh adult Elk kill with four yearling Druid Peak pack Wolves next to it southeast of the Lamar Valley Picnic Area. The carcass was intact and the Wolves must have just killed it. Three Wolves were about to start feeding.

A Bison bull walked up to the carcass and sniffed its head. The Wolves went to the rear of the carcass and

started tugging on that section as the bull continued to sniff the head area. This seemed to be the Wolves' first feeding on the kill. Three more Bison bulls approached the carcass. One Wolf at the carcass walked off a few steps with a tucked tail, then came right back and snarled at the nearest bull. The bulls walked toward the three Wolves, and the Wolves backed off. Two of the bulls sniffed the Elk's head. A Wolf sneaked back in and fed on the rear end.

Soon six bulls were at the site. They had a stand-off with the three Wolves at 0537 hrs. When one Wolf tried to approach the carcass, a bull ran at it, and the Wolf backed off. The other bulls walked toward the rest of the Wolves, and they scattered. The six bulls kept the three Wolves away from the carcass through 0554 hrs. At that time, the bulls left the site, and the Wolves moved to the carcass and fed. The three Wolves were still feeding on the kill when RM left at 0615 hrs.

In Wood Buffalo National Park, Alberta, mixed herds of Bison were observed forcing wolves away from wolf-killed Bison calves about 1 and about 4 months old (L. N. Carbyn, personal communication).

3. 3 March 2002 – Bison Attack Wounded Elk Calf

This incident was observed and video-taped by cinematographer Shane Moore in the Blacktail area of Yellowstone National Park. The tape was viewed by RM who transcribed the details summarized below.

The incident began when a herd of Bison ran 0.15 km downhill to a 9-month-old Elk calf with blood on its neck. Several Coyotes (*Canis latrans*) were nearby. The Bison herd gathered near the Elk, and over a 4-hr period, the Bison sniffed, licked, chased, and butted the Elk as the animal tried to seek refuge from the Coyotes by running into the Bison herd. The Bison butted the calf throughout the episode on 21 occasions during 40 minutes of videotaping, usually in the rear or side, and once knocked it into the air. At times the Elk was bedded or lying on its side when the Bison butted it.

Partway through the video, it was apparent that the Elk's abdomen was wounded, and an organ was hanging out. Moore believed that wound resulted from when he saw a Bison charge the Elk at full speed and hit it very hard in the side. Although the rest of the Bison herd then blocked the view, the calf stayed down for 20 minutes and when it arose, its abdomen had been ripped open.

Toward the end of the four-hour observation, the Bison drifted away from the wounded and bedded calf. As the calf continued to weaken, two Coyotes attacked it. Three additional Coyotes joined the attack, and the five Coyotes soon killed the calf.

4. 20 March 2002 – Bison Displace Wolves from Kill

Eleven members of the Druid Peak pack (11-months old and 23-months old; no adults) had been chasing Elk in the Hellroaring Creek area of Yellowknife National Park. At about 0931 hrs, the Wolves targeted a single cow Elk and pulled her down. A herd of about 39 Bison rushed to the downed Elk, chased the Wolves off, and surrounded the Elk tightly (0933 hrs). Suddenly the Elk leaped up. Two Wolves approached the Elk and nipped at it. The Elk ran through the Bison herd, and the two Wolves pursued it. After about 30 m the Elk fell. The Wolves were on it again for about 30 sec when the Bison chased them off again (0936 hrs). Later the Elk arose and almost immediately collapsed. The Elk arose a third time, ran a short distance and collapsed. She later tried to stand again but could only get up on her hind legs. A Bison butted the Elk's rear end and knocked her down, and the Bison herd surrounded the Elk again and kept the Wolves away. Each time a Wolf approached, a Bison would chase it 15-30 m. After a few minutes, the Wolves headed away up a hill and bedded (0946 hrs).

The Elk, while surrounded by Bison, kept raising her head and trying to get up. Usually the Bison stood closely around her but sometimes jumped back a few meters. The Bison remained tightly around the Elk from about 0939 hrs on. By about 1135 hrs, the Elk's head was no longer up and her body lay flat; she seemed dead. Ravens landed on or next to her, although the Bison still surrounded her closely. Bison licked or sniffed (we could not determine which) the carcass intermittently for several minutes.

The Wolves had returned at 0955 hrs and hung around 15-60 m from the Bison herd, and at various times some tried to reach the downed Elk. Each time, one or more Bison would skirmish with them and try to drive them off.

About 1253 hrs, the Bison started moving away from the Elk, and by 1305 hrs Wolves moved in. However, the Bison quickly returned and ran the Wolves off. This happened several times when Bison were both east and west of the Elk. Eventually, however, the Bison all grouped east of the Elk, and the 11 Wolves began to feed. The Bison then charged the Wolves and ran them off. Then the Wolves returned and chased the Bison away. In the next few minutes there were two additional standoffs at the carcass, and both times the Bison chased away the Wolves.

Such skirmishes continued as Wolves and Bison surged toward the Elk and each other, but gradually the Bison began to head a few meters farther east, and the Wolves became bolder. By 1313 hrs, the Wolves controlled the carcass and remained there and fed, while the Bison drifted off eastward. By 1350 hrs most of Wolves were done feeding and slept on a hill above the carcass, although individual Wolves fed later as well.

5. 22 March 2002 – Bison Roust Sleeping Wolves

In the same general area as observation 4 was made, eight of the 11 Druid Peak Pack Wolves seen on 20 March were sleeping at 0909 hrs when six Bison leading a larger herd (probably the same 39 seen there two days earlier) approached them. The Wolves arose, moved 100 m, and lay down again. Two minutes later, the Bison approached them to within 3 m, and the

Wolves again moved off 100 m and lay down. At 0918 hrs, a Bison approached one of the Wolves, which then confronted it; the other Wolves joined in harassing the Bison for 30 seconds.

The Wolves then left at 0920 hrs and moved 90° and a few hundred meters and lay down on a rocky ridge. Eventually the Bison followed and rousted the Wolves from there. Several more times the Bison followed the Wolves and rousted them out of their beds.

6. 16 April 2002 – Bison Bulls Displace Wolves from Kill

At 0826 hrs, RM saw 11 Druid pack Wolves (the breeding male, two yearlings, and eight 11-month-old pups) chase Elk about 1.6 km west of the Lamar Ranger Station. They pulled down a cow Elk at 0858 hrs. A few Bison bulls started moving toward them from the north. Two Bison ran into the site and chased the Wolves off. A yearling and two pups came right back to the carcass. One of the bulls returned to the site and chased off one of the Wolves.

At 0900 hrs several Wolves were feeding as four Bison bulls stood near the carcass. Two bulls charged the Wolves and drove them off, then stood close to the carcass.

At that point, five Wolves watched the carcass from 35 m away. The two bulls charged the breeding male and another Wolf, which fled eastward. The other Wolves ran to the kill and fed. The breeding male circled around and joined them.

A bull then walked to the carcass, and the feeding Wolves backed off a meter or so. The other nearby Bison approached the site. That bull charged the Wolves, and they ran off but came right back.

Both bulls then stood next to the Elk carcass and sniffed it. The bigger bull charged the Wolves, but as before the Wolves soon stopped, and the breeding male and three others returned to the site.

The two additional Bison bulls came toward the carcass from the west. One of the bulls shook his head, and some Wolves backed off a step or two. Other Wolves stood their ground and faced the bull which was about 6 m away. The bull shook his head again, but the Wolves continued to feed and ignored him.

The breeding male Wolf stepped away and ate some snow. When he returned to the carcass, a bull chased him off. The Wolf came right back. The same bull, which was the largest and most aggressive of the four bulls there, then drove all the Wolves off. The breeding male Wolf returned, and the big bull charged him. A second bull was standing a meter or so from the carcass. The big bull chased the breeding male Wolf southward, then returned to the site. The two bulls kept the Wolves from the kill until the bulls walked a short distance away at 09:12; the Wolves immediately ran in. All 11 fed or were near the site. As the two bulls walked off to the north a pup followed them.

Around 0920 hrs, three bulls approached the carcass from the northeast as the Wolves continued to feed. One pup headed westward, but the others stood their ground. The bulls turned back before they reached the site. A fourth bull chased a Wolf to the north of the carcass. One bull then ran in toward the carcass, but the Wolves countercharged, drove him away, and resumed feeding. A fifth bull was north of the carcass but did not yet approach it.

A sixth bull approached the kill, and a pup circled around to his rear and followed him. Another pup joined the first pup behind the bull. Two more of the original bulls approached the carcass from the north. The lead bull walked by the north side of the carcass with a raised tail. As another bull approached the site, the seven feeding Wolves backed off. At 0927 hrs three bulls remained at the carcass keeping the Wolves away. The breeding male Wolf stood nearby. He and a pup left, and the breeding male bedded north of the site at 0929 hrs. Eight other Wolves stood near the carcass.

At 0930 hrs two bulls started sparring with each other and began to drift away from the carcass. The breeding male Wolf and a yearling walked to the kill and fed. In the next minute other Wolves joined them. All six bulls remained away from the site, and the Wolves fed unmolested.

Discussion

The aggressiveness shown by Bison toward Elk and toward non-attacking Wolves is puzzling but might be some kind of hyperdefensive or hyperaggressive behavior. Predator harassment by several species of ungulates has been documented, and various explanations have been offered (summarized by Berger 1979), each involving ultimate reduction of predation risk. These explanations do not account for Bison attacking Elk, however. The most common element in our observations and those reported earlier of Bison attacking Elk was the presence of a weak or downed Elk and the butting, sniffing, and mobbing of it. In the Elk incidents involving Wolves, perhaps the presence of the predators was only incidental and made the Bisons' aggressiveness appear directed at keeping Wolves away from the carcasses or injured animals.

In other words, our observations might involve two phases of hyperaggressive behavior: (1) a general aggressiveness toward various intruders, perhaps as generalized anti-predator behavior that causes the Bison to approach intruders, and (2) continued aggressiveness toward intruders that do not flee, e.g., wounded animals or animals seeking refuge in the Bisons' herd because these animals persist in remaining nearby. This would also include Wolves that are trying to feed on carcasses near the Bison herd. Bison are so large and powerful that when a herd acts aggressively, it can charge and attack any animal with impunity, including Wolves and Grizzly Bears (*Ursus arctos*). Thus it may be generally advantageous for them to advertise this ability by harassing intruders persistently without making fine distinctions as to type.

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Notes

Morphology of Female Woodland Caribou, *Rangifer tarandus caribou*, in Saskatchewan

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Rettie, W. James. 2004. Morphology of female Woodland Caribou, *Rangifer tarandus caribou*, in Saskatchewan. Canadian Field-Naturalist 118(1): 119-121.

I obtained morphological measurements from captured female Woodland Caribou in central Saskatchewan. I found that only girth was a good predictor of body mass in adult animals. I also determined that Woodland Caribou from Saskatchewan, though similar in size and mass to alpine Woodland Caribou in Yukon, are larger than migratory Woodland Caribou and smaller than forest dwelling Woodland Caribou from western Alberta and Yukon.

Key Words: Woodland Caribou, *Rangifer tarandus caribou*, morphology, Saskatchewan.

Body sizes and body masses of subspecies and populations of *Rangifer tarandus* (Eurasian Reindeer and North American Caribou) vary considerably (e.g., Dauphiné 1976; Thomas 1982; Reimers 1983; Chan-McLeod et al. 1995) in response to a wide range of climatic and other environmental conditions (Skogland 1983; Reimers 1983). In North America, there is also a high degree of morphological variation within the Woodland Caribou subspecies (*R. t. caribou*). The best described populations of Woodland Caribou are those in Yukon (Gauthier and Farnell 1986; Kuzyk et al. 1999) and in Québec and Labrador (Parker 1981; Huot 1989). However, the subspecies has a more or less continuous distribution across northern Canada and the variations in climate, topography, and plant and animal communities across the range of the subspecies might be expected to favour different body sizes and masses in different areas. In particular, Skogland (1983) argued that morphology was density-dependent and related to the factors limiting population growth. Both Skogland (1983) and Chan-McLeod et al. (1999) reported that female *R. tarandus* that had reproduced successfully were significantly lighter the following winter than those that had not. Here, I present the first description of Woodland Caribou from central Saskatchewan and a discussion of their morphology relative to limiting factors.

Study Area and Methods

As part of research into population dynamics (Rettie and Messier 1998) and behaviour (Rettie and Messier 2000, 2001), I captured 43 female Woodland Caribou in central Saskatchewan (approximately 54° N to 55°30' N and 104° W to 109° W). All animals were captured in winter (dates between 13 December and 14 March) between March 1992 and January 1995. At the time of capture I used a flexible steel tape to measure the following parameters from most animals: total body length, body length to base of tail, girth (all to the nearest cm), mandible, and metatarsal lengths (to the nearest 5 mm). Methods followed those of Dauphiné (1976), modified for application to live animals. I measured body mass to the nearest kilogram for ten animals using an electronic load scale (Senstek, Saskatoon, Saskatchewan) suspended from a tripod or beneath a helicopter. I also extracted a tooth from most animals for aging. Further details on capture and aging appear in Rettie and Messier (1998). Animal capture and handling procedures followed animal care protocol number 920092 of the University of Saskatchewan.

Using natural log transformed values from the eight adult animals for which I had complete sets of data as well as body mass, I applied a stepwise multiple linear regression to assess the relationship of body measurements to body mass ($p = 0.05$ to enter, $p = 0.10$ to exit) and then applied the resulting equation to the morphometric data for all animals. I then tested for differences in calculated body mass for adult females that were accompanied by a calf at time of capture and those that were without a calf. All statistical analyses were conducted using SPSS for Windows Version 10.0.7 (SPSS Inc. 2000).

Results and Discussion

I had morphometric data from 34 adult animals (>31 months old at time of capture) and from three yearlings (19-22 months old at time of capture). The summary statistics for all measurements appear in

TABLE 1: Morphological measurements and actual and calculated body mass of adult female Woodland Caribou in central Saskatchewan.

Parameter	n	mean ± 1 sd	range
Actual body mass	9	131 ± 16 kg	96 – 156 kg
Calculated body mass*	32	118 ± 17 kg	96 – 160 kg
Body length to base of tail	33	191 ± 13 cm	165 – 217 cm
Total body length	33	206 ± 13 cm	177 – 230 cm
Metatarsal length	30	43.0 ± 1.4 cm	41.0 – 46.0 cm
Shoulder to hoof tip	15	115 ± 7 cm	102 – 126 cm
Girth	32	129 ± 11 cm	115 – 154 cm
Mandible length	32	31.4 ± 1.8 cm	28.0 – 35.0 cm

* Body mass kg calculated using the equation arising from the regression analysis: $e^{1.76\, ln\, \mathrm{Girth} - 3.78}$

TABLE 2: Morphological measurements and actual body mass of yearling female Woodland Caribou in central Saskatchewan.

Parameter	n	mean ± 1 sd	range
Actual body mass	1	98 kg	
Body length to base of tail	3	172 ± 3 cm	170 – 1175 cm
Total body length	3	185 ± 3 cm	182 – 1188 cm
Metatarsal length	3	41.7 ± 0.6 cm	41.0 – 142.0 cm
Girth	3	113 ± 3 cm	110 – 1116 cm
Mandible length	3	28.2 ± 2.0 cm	26.0 – 130.0 cm

Tables 1 (adult animals) and 2 (yearling animals). When compared to Yukon Woodland Caribou, the animals in Saskatchewan are almost as tall at the shoulder (115 cm vs. 116 cm), are the same girth (129 cm), but are not as long (191 cm vs. 206 cm) as the alpine animals measured by Kuzyk et al. (1999). Saskatchewan caribou are smaller than forest dwelling Woodland Caribou from Yukon (Kuzyk et al. 1999) and from western Alberta (Gauthier and Farnell 1986) in all comparable parameters.

From the regression analysis, I concluded that only girth was significantly related to body mass (p =0.04, $r^2 = 0.78$). I used the resulting equation, where girth is measured in cm:

$$\text{calculated body mass (kg)} = e^{(1.76 ln \mathrm{Girth} - 3.78}$$

to calculate body mass for all adult animals for which I had girth measurements. The calculated body mass values appear in Table 1. Figure 1 shows the relationship between girth and body mass and its 95% prediction interval. Untransformed data are presented in the figure while analyses were based on natural log transformed data. The wide prediction interval in Figure 1 suggests that further sampling is required to reduce uncertainty in the girth-body mass relationship. The relationship is particularly weak for smaller girths where the relationship is influenced by a single observation. Though the summarised measurements present a reference point for future studies on morphological variation in Woodland Caribou, the prediction of body mass from body measurement and the equation presented should be made cautiously (Cattet et al. 1997). Finally, I did not detect a difference in calculated body mass between adult animals with and without a calf-at-heel at time of capture (t-test, $t = 0.30$, df = 30, $p = 0.76$).

Skogland (1983) argued that body sizes in *R. tarandus* were density-dependent, the larger body size

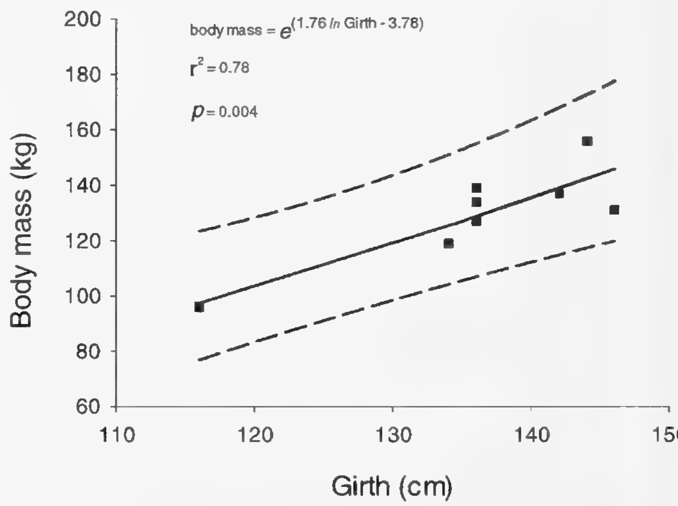

FIGURE 1. Relationship between girth (cm) and body mass (kg) for adult female Woodland Caribou in Saskatchewan. Solid line represents the equation derived through multiple linear regression; dashed lines represent the 95% prediction interval of the equation. Filled squares represent data used to derive the equation.

in North American Caribou being attributed to their low densities, a consequence of limitation by predation rather than by food resources. Amongst Woodland Caribou populations, the George River Caribou Herd in Quebec and Labrador is food limited and contains the smallest individuals (Parker 1981; Huot 1989). The body sizes of Woodland Caribou in Saskatchewan are larger than George River Herd animals and support the argument that Saskatchewan populations are not food limited (Rettie and Messier 1998). As with the larger animals in Caribou populations in western Alberta and Yukon (Edmonds 1988; Kuzyk et al. 1999), predation is the likely proximate limiting factor for Saskatchewan Woodland Caribou populations (Rettie and Messier 1998).

Skogland (1983) also suggested that predator induced constraints on lifetime reproductive success led to larger body size in North American Caribou by delaying reproductive maturity in favour of increased somatic growth. However, yearling female Woodland Caribou in Saskatchewan were not only pregnant (Rettie and Messier 1998) but larger than both adult Reindeer (Skogland 1983) and adult migratory Woodland Caribou (Huot 1989). Relative to observations in Norway, there does not appear to be a trade off being made between reproduction and somatic growth. Instead, Saskatchewan Woodland Caribou appear able to mature as yearlings and still achieve large adult body sizes. My failure to detect differences in body mass between reproductive classes may represent a lack of difference, result from a poor predictive ability of my equation for body mass, or be a consequence of interannual variation as reported by Chan-McLeod et al. (1999).

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Occurrence of Parasitoid Wasps, *Baeus* sp. and *Gelis* sp., in the Egg Sacs of the Wolf Spiders *Pardosa moesta* and *Pardosa sternalis* (Araneae, Lycosidae) in Southeastern Idaho

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Cobb, Lisa M., and Vincent A. Cobb. 2004. Occurrence of parasitoid wasps, *Baeus* sp. and *Gelis* sp., in the egg sacs of the wolf spiders, *Pardosa moesta* and *Pardosa sternalis* (Araneae, Lycosidae) in southeastern Idaho. Canadian Field-Naturalist 118(1): 122-123.

Egg sacs of the wolf spiders *Pardosa moesta* and *Pardosa sternalis* were sampled for two years during June to September in southeastern Idaho. Parasitoid wasps, *Baeus* sp. (Sceleonidae) and *Gelis* sp. (Ichneumonidae), were observed in the egg sacs of both *Pardosa* species. Of 322 egg sacs examined, 14.6% were parasitized. Parasitism of egg sacs occurred throughout most of the *Pardosa* egg sac-carrying season.

Key Words: Wolf Spider, *Pardosa moesta*, *P. sternalis*, egg sac, predation, parasitic wasps, *Baeus* sp., *Gelis* sp., parasitoid, reproduction.

Parasitic wasps are well known predators of spiders and may serve as either ectoparasites (e.g., externally feeding on the body) or endoparasites (e.g., feeding on eggs and developing young within egg sacs) (Foelix 1982). Larval endoparasites that consume spiders eggs are classified as parasitoids (Roberts and Janovy 2000) with the most speciose family of parasitoid wasps being the Ichneumonidae (Godfray 1994). To parasitize a spider egg sac, wasps insert their ovipositor into the wall of the egg sac and lay eggs which develop into larvae and predate the spider eggs (Austin 1985).

Female wolf spiders (Lycosidae) have the conspicuous behavior of carrying their egg sacs attached to their spinnerets. Although it would appear that such behavior could provide substantial maternal care, parasitism of egg sacs still occurs. The wasps *Baeus* (Scelionidae) and *Gelis* (Ichneumonidae) have been found in previous studies to be common parasitoids of Lycosidae egg sacs (Kaston 1948; Edgar 1971a; Austin 1985).

Wolf spiders in the genus *Pardosa* are common ground-dwelling spiders throughout much of the northern hemisphere (Edgar 1971b; Dondale and Redner 1990; Buddle et al. 2000). Their reproductive period may last several months (Edgar 1971b; Cobb 1992; Buddle 2000) and some species may produce multiple clutches during a single season (Edgar 1971b; Wolff 1981).

The main focus of this study was an investigation of the reproductive ecology of *P. moesta* (Banks) and *P. sternalis* (Thorell) in eastern Idaho. Cobb (1992) suggested that in southeastern Idaho both species have a tendency to produce multiple clutches within a season. During the study, *P. moesta* and *P. sternalis* females and their egg sacs were collected between one and five times per month from June through September of 1990 and 1991. All collections occurred in a two hectare meadow near the base of Scout Mountain (Caribou National Forest, Bannock County, Idaho) at an elevation of approximately 2000 m. During the late spring and early summer the meadow was marshy, fed by a mountain stream. However, in late summer and early fall the meadow was dry and had been grazed by cattle. For each spider and corresponding egg sac we collected a variety of morphometric data, which included female mass, clutch mass, and clutch size. While examining the egg sacs we discovered several of them were parasitized.

Identifiable parasitoids of *P. moesta* and *P. stenalis* egg sacs were wasps of the families Scelionidae and Ichneumonidae. P. M. Marsh, of the USDA Agricultural Research Station, Beltsville, Maryland, identified the scelionid specimens as *Baeus* sp., and the ichneumonids at *Gelis* sp. All but two of the identifiable parasitoids for both *Pardosa* species were *Baeus* sp. Two egg sacs of *P. sternalis* were found with a single *Gelis* sp. each. The *Gelis* were collected on 23 June and 22 July 1991. Pupal parasitoids inside the egg sacs could not be identified to species. Because not all individual parasitoids could be identified, other parasitoid genera may have been present in the egg sacs.

Of 134 egg sacs for *P. moesta* and 188 egg sacs for *P. sternalis*, 47 were infected with parasitoids (14.6% parasitism overall). Within these infected egg sacs 281 parasitoids were counted. Parasitism rate was 12.7% for *P. moesta* and 16% for *P. sternalis* (Table 1). Egg sacs were found parasitized from June to September for *P. moesta* and *P. sternalis*. During mid and late May 1990, a sample of egg sacs was collected from *P. sternalis* but none contained parasitoids. All of the *P. sternalis* egg sacs in the May collection contained eggs only and no spider instar stages, indicating egg

TABLE 1. Number of parasitized egg sacs for *Pardosa moesta* (n = 134) and *Pardosa sternalis* (n = 188) from southeastern Idaho. Data are represented as number of egg sacs with parasitoids (number of egg sacs sampled).

	P. moesta		*P. sternalis*	
Month	1990	1991	1990	1991
June	0 (23)	–	8 (37)	1 (8)
July	1 (40)	1 (9)	7 (45)	3 (30)
August	12 (25)	–	6 (15)	1 (21)
September	0 (27)	3(10)	2 (17)	2 (15)

sac formation had begun only recently. The number of parasitoids per egg sac varied considerably. Mean (± SE) number of parasitoids per egg sac for *P. moesta* was $\bar{x}$ = 5.1 ± 1.4 (range = 2 - 15) in 1990 and $\bar{x}$ = 6.5 ± 2.3 (range = 1 - 12) in 1991. For *P. sternalis*, the number of parasitoids per egg sac was $\bar{x}$ = 5.7 ± 1.6 (range = 1 - 37) in 1990 and $\bar{x}$ = 8.4 ± 4.6 (range = 1 - 35) in 1991.

This study indicates that parasitism occurred throughout the egg carrying season and was highest in August 1990 and September 1991. Interestingly, these high parasitism rates correspond to times when *Pardosa* in this region are producing smaller egg clutches (Cobb 1992). Several species of *Pardosa* have their greatest reproductive output early in the reproductive season and produce smaller egg sacs and fewer eggs later in the season (Eason 1969). Potentially, these higher parasitism rates in the late summer could have resulted in selection for greater spring reproduction in *Pardosa*. Although parasitism has been documented for several species of *Pardosa* (Eason et al. 1967), recorded levels of parasitism are uncommon and variable. Eason (1969) indicated egg parasitism rates of less than one percent in *P. lapidicina* in Arkansas, while Edgar (1971a) observed levels that ranged from 3% to 35% in Scotland. Our data indicate variable and sometimes high levels of parasitism as well. Such high levels of parasitism have been shown to reduce the number of spiders in the field (van Baarlen et al. 1994) as well as the recruitment of young (Edgar 1971a). Although we have documented seasonal variation in parasitism rate, we do not know if these *Pardosa* populations are being negatively impacted by parasitoids.

Acknowledgments

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The Northern True Katydid, *Pterophylla camellifolia* (Orthoptera: Pseudophyllidae), at Ottawa, Ontario

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Darbyshire, Stephen J. 2004. The True Katydid (*Pterophylla camellifolia*) at Ottawa, Ontario. Canadian Field-Naturalist 118(1): 124-126.

Five males of the Northern True Katydid (*Pterophylla camellifolia*) are reported from Ottawa, Ontario (approximately 45°25'N, 75°42'W), in 2001 and 2002 at three separate locations. Based on its distribution and habits extralimital occurrences in Ottawa are likely due to chance introduction.

Key Words: Northern True Katydid, *Pterophylla camellifolia*, Ontario, distribution, insect dispersal.

In mid-August 2001 two male Northern True Katydids, *Pterophylla camellifolia* (Fabricius), were heard calling at a site in an urban residential area of eastern Ottawa, Ontario (location 1, Figure 1). Calling continued until about 9 October when daily minimum temperatures fell below freezing. Calling perches in trees were located between 5 and 10 metres above the ground. Several species of trees were utilized, including Sugar Maple (*Acer sacharrum* Marsh.), Norway Spruce (*Abies balsamea* (L.) Mill.) and Red Oak (*Quercus rubra* L.). Over the calling period they moved short distances (less than 50 metres horizontally) from one tree to another, but were never heard calling together in the same tree (it was assumed that the two males heard repeatedly were the same two individuals). *Pterophylla camellifolia* is not usually associated with coniferous trees and the Norway Spruce was occupied for only a single night.

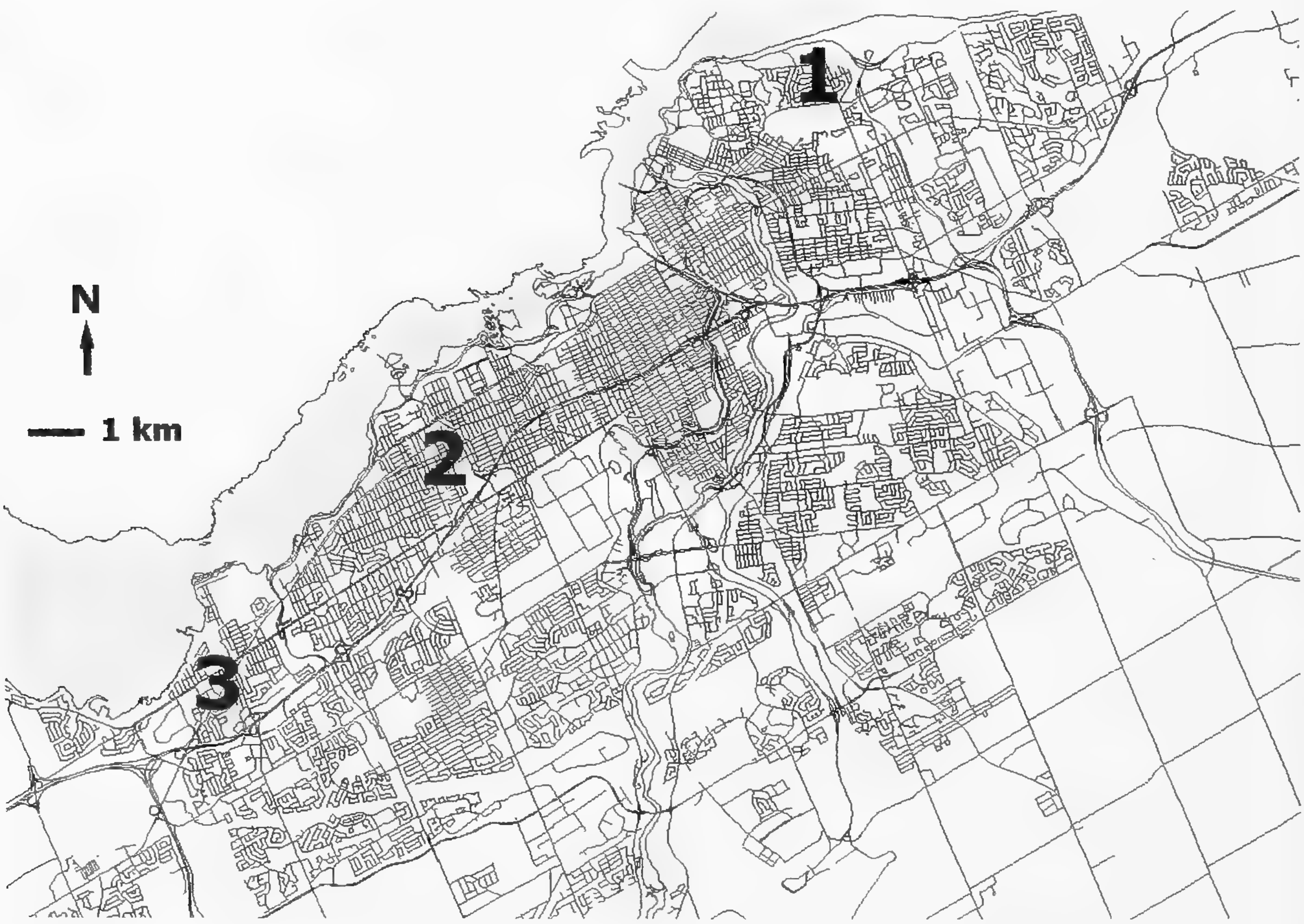

FIGURE 1. Map of the Ottawa urban area showing the locations of calling males of *Pterophylla camellifolia*, approximately 45°25'N, 75°42'W. Location 1: two males in 2001; location 2: one male in 2002; location 3: two males in 2002.

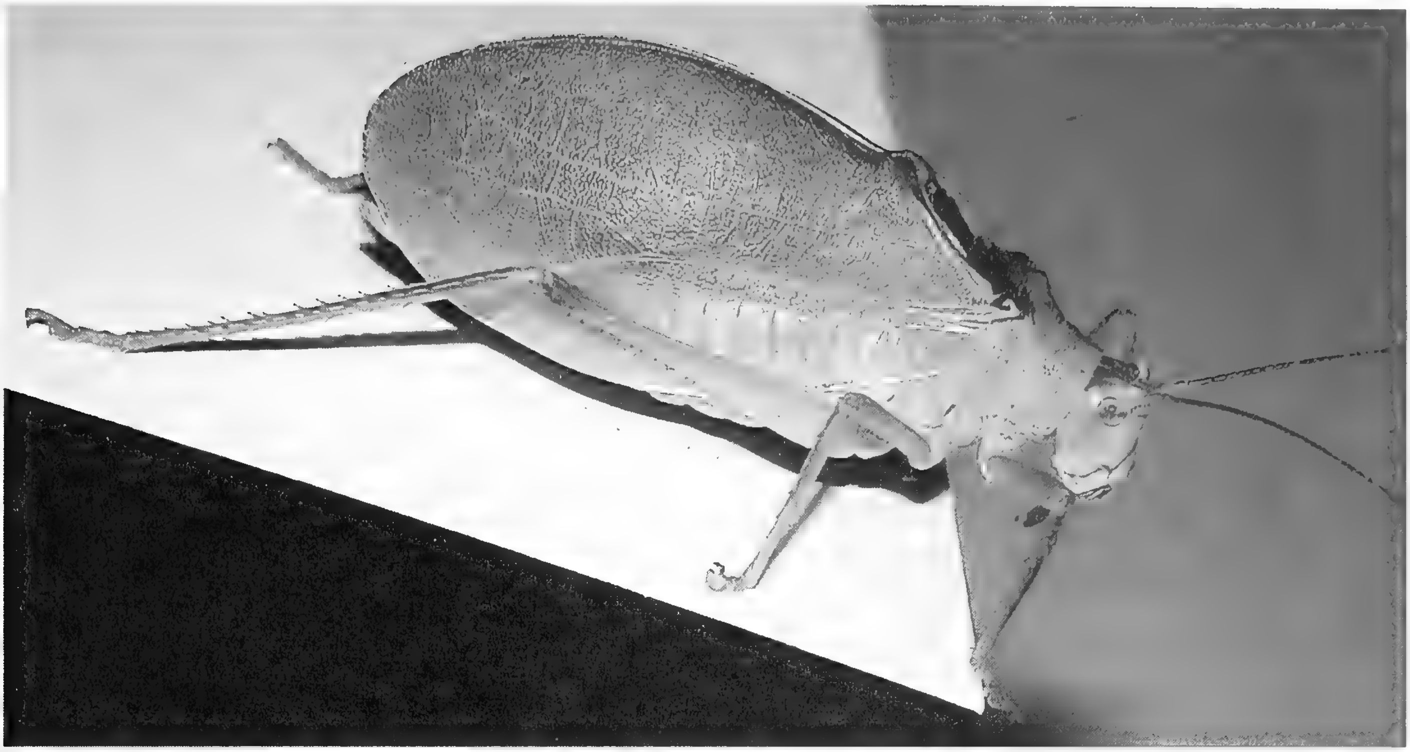

FIGURE 2. Male *Pterophylla camellifolia* from Ottawa, Ontario (location 3, Figure 1). Photographed 19 September 2002.

Katydids were also heard calling in August, September, and early October 2002 at two other locations within urban Ottawa (locations 2 and 3, Figure 1). At location 2 (Figure 1) a single male was heard calling from a large silver maple (*Acer saccharinum* L.) at a height of about 10 metres. It remained in the same tree throughout the observation period (about two months). At location 3 (Figure 1), two individuals were heard calling in a landscaped area around a large apartment complex. Perches were about three to four metres high in English Oak (*Quercus robur* L.) and Crab Apple (*Malus* sp.). Calling continued at these two locations until about 10 October, when night-time temperatures began to approach freezing.

Since the insect is univoltine (Riley 1874; Caudell 1906; Hebard 1941), searches were made of about 1 km^2 around location 1 in September 2002 and 2003 and about 0.5 km^2 around locations 2 and 3 in September 2003. Although repeated searches were made on warm evenings after complete darkness, no individuals were heard calling at location 1 in 2002, or at any of the sites in 2003.

The range of *Pterophylla camellifolia* is reported to be from Massachusetts to north-central Florida, westward through southern New York, southern Ontario and Michigan to Iowa, Kansas, Oklahoma and eastern Texas (Hebard 1941; Vickery and Kevan 1983). Caulfield (1887) was the first to report the species in Ontario (under the name *Platyphyllum concavum*). The known distribution is primarily along the north shore of Lake Erie from the Niagara Peninsula to Essex County in southwestern Ontario and largely coincident to the Carolinian forest region (Vickery and Kevan 1985).

The family Pseudophyllidae contains about 1000, mostly tropical, species. In Canada, the only representative of the family is *Pterophylla camellifolia*. Although there are a few similar large green tettigoniid species in eastern Canada, *P. camellifolia* is readily distinguished morphologically by its large size (about 25-50 mm) and its ovate, strongly convex tegmina (outer or front wings) which are slightly longer than the abdomen (Vickery and Kevan 1983, 1985). The loud onomatopoeic stridulations (chirps) also readily distinguish this species (audio file: Walker and Moore 2003*). Differences in pulse number and pulse frequency of the chirp occur throughout the range of the species (Alexander 1968) and with environmental conditions (Shaw 1975). The most common chirp is of three to five pulses followed by a short pause (Caudell 1906). Males heard in Ottawa produced three, or sometimes two or four, pulses per chirp. Hebard (1941) recognized two species of *Pterophylla* in the United States, one restricted to Florida and the other widespread in North America with considerable variation suggesting a single polymorphic species with five geographic races (subspecies). The northern type present in Ontario is *P. camellifolia camellifolia*.

Blatchley (1920) stated that open forests are preferred, although Hebard (1941) found the insect most common in dense forests, particularly where large oaks occur. Calling perches are usually in canopies whenever tall trees are present, 25 to 100 feet (7.6-30.5 m) or above (Hebard 1941; Shaw and Carlson 1969). Where tall trees are absent, calling will occur from lower perches in small trees, orchards and shrubbery (Caudell 1906; Blatchley 1920; Hebard 1941). This is consistent with the observations of individuals in Ottawa.

Throughout most of the species' range males mature and begin calling in July and continue through to the advent of cold weather: late July to late September or early October in Iowa (Shaw and Carlson 1969); late July to early October (rarely to early November) in Washington, D.C. (Caudell 1906); 30 July to 10 October in Michigan (Cantrall 1968); and, 10 July to 27 October in Indiana (Blatchley 1920). During the first severe frosts of autumn the insects fall to the ground (Hebard 1941) and perish unless the weather subsequently moderates.

Although possessed of tegmina and hind wings, *Pterophylla camellifolia* does not fly, the wings being used to parachute or glide from one perch to a lower one or to the ground (Caudell 1906; Hebard 1941; Shaw and Carlson 1969; Vickery and Kevan 1985). When on the ground or accessing higher perches they walk. Individuals normally travel only short distances during their lifetime (Caudell 1906; Hebard 1941), but may often move from tree to tree.

The Northern True Katydid seems to be expanding its range northwards and westwards, with recent reports placing calling males in southern Minnesota (as far north as the Twin Cities area) (Tekiela 2002*), southeastern North Dakota (Walker and Moore 2003*), and Colorado (Weissmann and Leatherman 1992; Walker and Moore 2003*). In Ontario recent sightings have been at Barrie (Sinclair 1998*) and Toronto (D. A. Sutherland, personal communication).

What are the mechanisms by which this large flightless insect could expand its range northward and westward to areas distant from its previous distribution? The new extralimital records in Ontario come from more-or-less urban regions, which suggests that inadvertent human transportation is involved. The apparently independent immigrations detected in the Ottawa area have been to well-established residential areas where commercial truck or rail traffic would not be a likely mechanism. It seems possible that nymphs or adults may be carried on non-commercial vehicles moving from southern regions during the early part of the summer. A trip from the contiguous range to the Ottawa area would take a minimum of 8-10 hours. The highway system and vehicle traffic have made such a trip possible for many decades now, yet immigration has been noticed only recently. As it is one of the loudest insects in North America, the presence of mature males in residential areas is very conspicuous in spite of their cryptic green colouration and usually inaccessible calling perches. No females have been found in the Ottawa area yet and there is no evidence of an established breeding population.

Acknowledgments

D. A. Sutherland (Natural Heritage Information Centre, Peterborough, Ontario) provided observations on the occurrence of *P. camellifolia* in Toronto and discussed aspects of dispersal. Jean-François Landry and Henri Goulet (Agriculture and Agri-Food Canada, Ottawa, Ontario) kindly read earlier versions of the manuscript and provided constructive criticism.

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Record High Wolf, *Canis lupus*, Pack Density

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This report documents a year-around Wolf (*Canis lupus*) density of 18.2/100 km^2 and a summer density of 30.8/100 km^2, in a northeastern Minnesota Wolf pack. The previous record was a summer density of 14.1/100 km^2, for a Wolf pack on Vancouver Island, British Columbia, Canada.

Key Words: Wolf, *Canis lupus*, Minnesota, Superior National Forest, White-tailed Deer, *Odocoileus virginianus*.

Wolf (*Canis lupus*) densities are highly variable (Mech 1970), depending generally on prey biomass density (Keith 1983; Fuller 1989). Because prey biomass density is related inversely to latitude, Wolves tend to reach their highest densities at lower latitudes (Mech and Boitani 2003). The highest reported naturally occurring Wolf density is 14.1 Wolves/100 km^2 for a pack of nine Wolves on Vancouver Island (Scott and Shackleton 1982).

Herein we report on a Minnesota Wolf pack with a density higher for two years than the highest density reported elsewhere.

Study area

We studied the Farm Lake Wolf pack (FLP) that inhabited the Superior National Forest (SNF) of northeastern Minnesota where most of the Wolf's diet is White-tailed Deer (*Odocoileus virginianus*). The Wolf packs in the SNF are spaced into territories (Mech 1973, 1986) and the FLP territory, 10.0 km east of Ely (48°N, 92°W), was surrounded by four or five other pack territories. The terrain, vegetation, and land use in the territory are typical of the surrounding region (Mech 1973). However, during winter, much of the territory encompasses part of the Garden Lake deer yard (Nelson and Mech 1981). Deer densities there in the late 1970s were estimated at 16-23 deer/km^2 (Nelson and Mech 1981), and the deer population in the general area has increased considerably since then (Mech and Nelson 2000).

Methods

Wolves were live-trapped, radio-tagged, aerially radio-tracked weekly when possible, and aerially observed with their packs during winter. Estimates of FLP territory size were made for summer (1 April–30 September), winter (1 October–31 March) and the entire year (1 April–31 March) from 1 October 1997 through 30 March 1999.

We used ArcView (copyrighted) GIS (ESRI Inc., Redlands, California) to estimate each period's territory area corresponding to the combination of all FLP radio-tagged Wolves. UTM coordinates of the FLP Wolf locations were imported into ArcView GIS and converted into point data. Minimum Convex Polygons (Mohr 1947) were then constructed using Animal Movement (Hooge and Eichenlaub 1997) extension to Arcview.

By using observation curve analysis we determined when a territory was defined (Odum and Kuenzler 1955). We subsampled period Wolf locations without replacement, increasing the number of samples (locations) with each subsample treatment, and calculated territory area from each subsample. Five repetitions of each subsample were performed to generate a corresponding mean territory area for each subsample. The mean areas were then plotted against number of locations in the subsample. We considered territories defined when there was ≤1% change in area (suggesting asymptotic behavior) as a result of the addition of one more sample.

We determined pack size through the winter aerial surveys. The greatest number of Wolves seen was considered the pack size. Vegetative cover prevented aerial surveys in summer. Pack sizes were divided by their territory size and then multiplied by 100 to give density in Wolves/100 km^2.

Results

We radio-tagged and tracked adult female Wolf 667 and male pup 673 (born in 1997) from 1 October 1997 through 30 March 1999 for this study (Table 1). A total of 127 Wolf locations were obtained, with one Wolf location defined as when one Wolf was at a point. If both Wolves were together, two locations were recorded. Observation curve analysis suggested that 30 locations were needed to accurately define the winter 1997-1998 FLP territory, 50 samples for the 1998-1999

TABLE 1. Background data for calculations of Wolf density in the Farm Lake Pack, northeastern Minnesota.

Period	Number of Locations	Number of Wolves	Area km^2	Density/100 km^2
1 October 1997 – 30 March 1998	39	4	22.88	17.5
1 April 1998 – 30 September 1998	44	–	19.50	30.8*
1 October 1998 – 30 March 1999	44	6	32.88	18.2
1 April 1998 – 30 March 1999	88	6	32.88	18.2

*Assuming only six Wolves, the number observed during the following winter.

territory, and 30 and 35 samples for the FLP summer and winter periods, respectively. In all these periods, these criteria were met (Table 1).

During winter 1997-1998, the FLP contained four members and used an estimated area of 22.88 km^2, a density of 17.5 Wolves/100 km^2. In winter 1998-1999, six FLP Wolves used an area of 32.88 km^2, a density of 18.2 Wolves/100 km^2, and in summer only 19.5 km^2 for a minimum density of 30.8 Wolves/100 km^2 (Table 1).

Discussion

The Wolf densities we found exceeded the highest previous record of 14.1 Wolves/100 km^2 for a Wolf pack on Vancouver Island (Scott and Shackleton 1982). Hebert et al. (1982), citing the Scott and Shackleton (1982) study, claimed a density of one Wolf per 6.3 km, or 15.9/100 km^2. However, Hebert et al. (1982) included a third pack not mentioned by Scott and Shackleton and presented no territory area data for this pack. Density estimates using radio-locations can be greatly influenced by the number and timing of locations. Our locations were evenly distributed throughout the year and met the observation curve test (Odum and Kuenzler 1955), even though the number of locations available were fewer than recommended by others (Fritts and Mech 1981; Bekoff and Mech 1984; Ballard et al. 1987). No doubt the much smaller size of our territory explains why fewer locations were needed to define it.

It is notable that the previous high record Wolf density (14.1 Wolves/100 km^2) was based only on summer locations during a relatively short period (11 April to 10 September). Furthermore, this period was before when most of the year's mortality occurs (Fuller et al. 2003). Thus the earlier density is not strictly comparable to either our year-around or winter densities.

The extraordinarily small FLP territory areas of 1997-1998 and 1998-1999 resulted in the highest documented Wolf density to date. This density was no doubt related to the high winter deer density in the area as well as to the relatively harsh winters during that period, with deep snow and extreme cold, that would have caused deer to concentrate with greater density. We know of no garbage dump or other regular source of food in this territory.

Even so, our highest Wolf density (30.8 Wolves/100 km^2) occurred in summer, and it was a minimum estimate because it was based on the pack size the following winter, after any mortality may have occurred. Thus the winter deer density at first seems irrelevant. However, possibly such a high deer density allowed the Wolves to add sufficient fat and to cache enough surplus food to help carry them through the summer. In any case, this study demonstrates the extreme density that Wolf densities can reach when prey is plentiful.

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Extraordinary Size and Survival of American Black Duck, *Anas rubripes*, Broods

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Two female American Black Ducks (*Anas rubripes*) were initially observed during June 1982 with 20 Class Ib or 18-22 Class Ia-b ducklings in two wetlands in Hancock County, Cherryfield, Maine. Fifteen of 20 ducklings (75%) in one brood and 16 of 18-22 ducklings (72-89%) in the other brood survived to fledge. These large broods probably resulted from post-hatch brood amalgamation.

Key Words: American Black Duck, *Anas rubripes*, brood size, duckling survival, post-hatch brood amalgamation, Maine.

Exceptionally large broods of North American dabbling ducks (*Anas* spp.) that exceed average clutch size (8-10 eggs, Zammuto 1986) occur when females (1) lay extraordinarily large clutches, (2) lay eggs in nests of conspecifics ("pre-hatch brood amalgamation" (Pre-HBA), or brood parasitism; Eadie et al. 1988), or (3) hatch their own clutches and acquire the brood of another female ("post-hatch brood amalgamation" (Post-HBA); Eadie et al. 1988). Pre-HBA, which can be either inter- or intra-specific, and post-HBA occur infrequently in the Anatini; only 3 of 9 species of Anatini were reported by Eadie et al. (1988) for either type. Tufts (1986) in Nova Scotia reported brood amalgamation for three American Black Duck broods when he released orphaned ducklings near females with broods. Herein, we report two records of probable post-HBA resulting in two extremely large broods of wild American Black Ducks in Maine.

Study Area and Methods

We observed the two broods in two Beaver (*Castor canadensis*) flowages (Snake Flowage, 44°37'N, 68°06'; BFA Flowage, 44° 39'N, 68°07'W) that were 20 km northwest of Cherryfield, Maine, in township T10 SD, a forested area that has negligible acid-neutralizing capacity and low nutrients in wetlands (Norton 1980). We obtained morphometric and water chemistry characteristics of wetlands by methods of McAuley and Longcore (1988). We mapped and classified (Cowardin et al. 1979) both wetlands, and we sampled invertebrates in one (Snake Flowage), as part of related fieldwork (J. R. Longcore, unpublished data). All observations of broods followed the survey protocol of Longcore and Ringelman (1980). Morning visits on wetlands began 0.5 hour before sunrise and lasted two hours; the 2-h evening visit ended ≥0.5 hour after sunset. Broods were always sought on both wetlands simultaneously, and observers scanned wetlands with binoculars (7×50) and spotting scopes (20-60×) from elevated (4-5 m high) platforms. We backdated brood age (Gollop and Marshall 1954*) to determine approximate dates that first eggs were laid.

Results

During 3 June – 12 July 1982. we observed two American Black Duck broods that were twice (20 and 18-22 ducklings) the size of average broods. Each brood was seen three times. Both broods were seen on the same wetland on the same day (8 June) by DGM. Both broods were observed on 12 July during the even-

Table 1. Characteristics of the two brood-rearing wetlands with the large American Black Duck broods in Cherryfield, Maine, 1982.

Variable	Snake Flowage	BFA Flowage
Wetland System, Class	Palustrine, Forested Wetland	Palustrine, Forested Wetland
Basin area (ha)	4.9	4.5
Surface water area (ha)	4.9	3.4
% Submergents	10	78
% Emergents	28	22
% Flooded timber	41	78
pH (in situ)	5.51	6.13
Alkalinity (μeq L^{-1})	58.8	83.0
Conductivity (μS cm^{-1})	24.0	23.0
Calcium (μeq L^{-1})	59.4	77.5
Phosphorus (ug L^{-1})	70	170
Color (Hazen units)	170	150

ing visit, each by a different observer on a different wetland, thereby corroborating that two different broods existed as first identified by plumage characteristics (Gollop and Marshall 1954*). The brood of 20 declined to 15 (75% survival) and the brood of 18-22 declined to 16 (73 or 89% survival) at Class III size near fledging. The features of the two wetlands are described by the variables in Table 1. We sampled invertebrates in Snake Flowage, which contained the highest ($P < 0.0001$) number of aquatic Insecta per sample (mean = 257) compared with nine other wetlands sampled in the area (J. R. Longcore, unpublished data).

Discussion

At Moosehorn National Wildlife Refuge, Maine, and at Lake Dalhousie, Nova Scotia (J. R. Longcore, unpublished data), we have observed Class III American Black Duck broods of 10 ducklings, which are near mean clutch size. The two large broods, however, were twice the clutch size (mean ±1 SD) of American Black Ducks in Maine (10.4 ±1.3), in Vermont (9.6 ±1.8; Coulter and Miller 1968), in Maryland (9.1 ±1.8; Stotts and Davis 1960), or in Quebec (9.2 ± 1.7; Reed 1970). Other studies of American Black Ducks have reported large clutches but rarely as large as the broods we observed. Reed (1970) reported sizes of mostly first clutches during 12-25 April, as 13, 14, 15, and 17 eggs in Quebec. Both Coulter and Miller (1968) and Stotts and Davis (1960) reported clutch sizes of 14 or 15 eggs, and Krementz et al. (1991) reported that in 1982 American Black Ducks nesting on islands in Chesapeake Bay averaged 10.2 ± 3.0 eggs per clutch, ranging from 7-20 eggs, but it was unknown whether large clutches were from one female.

For our two wetlands adequate food seemed available for females to lay large clutches because the highest mean number of invertebrates per sweep net sample was from Snake Flowage among 10 wetlands sampled (J. R. Longcore, unpublished data). By backdating clutches we determined that these females, if they laid the entire clutch, would have initiated egg laying about 7 and 14 April, similar to early egg dates of 1-10 April for Maine and Vermont (Coulter and Miller 1968). Although ducks may adjust clutch size to environmental conditions (Skutch 1967), if these two females had laid 20 to 22 eggs per clutch, mass of the clutch would have been 1248 – 1373 g (62.4 g/egg × 20 or 22 eggs), which would have equaled or exceeded mass of a female and been >2 times the average mass of a usual clutch (mean = 580.3 g, Arnold 1988). Therefore, it is possible that each female produced the entire clutch for these large broods, but it seems improbable.

The possibility of intra-specific pre-HBA (hatch brood amalgamation) is supported by Stotts and Davis (1960) who reported two instances of American Black Duck females laying eggs in the nest of another female. They (Stotts and Davis 1960: 145) also commented that "Eleven others [clutches] may have been the result of similar parasitism (a total prevalence of 1.8 percent)." An example of inter-specific pre-HBA also was recorded by Stotts and Davis (1960) who documented that an American Black Duck female began laying in a Mallard (*Anas platyrhynchos*) nest that contained five eggs. The Mallard laid four more eggs before deserting, but the American Black Duck laid 11 eggs to equal a 20-egg mixed clutch. Also, they reported that two American Black Duck females nested within 46 cm of each other on an offshore duck blind in Chesapeake Bay, Maryland; one female gradually incorporated the other's clutch into her own and incubated all eggs (Stotts and Davis 1960: 142). Large clutches associated with ducks nesting on islands, however, may be related to high nest density (i.e., 25.2 – 35.7 nests/ha on Bodkin Island, Chesapeake Bay, Krementz et al. 1991); but is uncommon elsewhere (e.g., 0.06 – 0.12 nest/ha in Maine bogs (Coulter and Miller 1968: 35). Because nest sites are not limiting in Maine or across the breeding range, nesting females are widely dispersed, except on islands (Coulter and Miller 1968), nests are well hidden (Bent 1923), and females are secretive when returning to nests in twilight hours (J. R. Longcore, unpublished data), it seems improbable that our large broods resulted from intra-specific pre-HBA (Beauchamp 1997). The third explanation for the large broods is intra-specific post-HBA. For this scenario, two additional clutches of 10-12 eggs must have hatched at the same time and ducklings in those broods were then acquired by the females that we observed. We know that two other American Black Duck broods (i.e., of five and 10 ducklings) used Snake Flowage at the same time as the large broods. To account for this scenario of post-HBA, six American Black Duck broods of similar age must have been associated with these two wetlands. Concentration of broods on high quality

wetlands is common (Longcore et al. 1998); indeed these two wetlands also supported one Green-winged Teal (*Anas crecca*), three Wood Duck (*Aix sponsa*), and four Hooded Merganser (*Lophodytes cucullatus*) broods. For the 20-duckling brood, JRL recorded on 24 June that some ducklings appeared to be in different age Classes (i.e, IIb and IIc), which suggests post-HBA; however, the duckling brood of 18-22 appeared as all the same age to DGM. The two brood-rearing females were large, extremely attentive, and especially adept in eliciting rapid responses from ducklings by uttering a few low calls. Although females are capable of laying large clutches and the remote possibility of nest parasitism (pre-HBA) exists, we conclude that the most plausible explanation for these two large broods was intra-specific post-HBA.

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Observations of Interactions between Puma, *Puma concolor,* and Introduced European Red Deer, *Cervus elaphus,* in Patagonia

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Direct observations of interactions between native Puma *(Puma concolor)* and introduced European Red Deer *(Cervus elaphus)* in Patagonia are discussed with respect to the absence of evolutionary sympatry. Although the founding stock of European Red Deer had been lacking natural predation pressure for considerable time due to the previous extinction of large predators, these observations suggested that inherent antipredator behavior of European Red Deer toward this novel predator, once detected, was effective and may partially explain the success of European Red Deer as an invasive species. Puma behavior supported the view that they are a generalist predator which opportunistically utilizes new prey species like European Red Deer.

Key Words: European Red Deer, *Cervus elaphus,* Puma, *Puma concolor,* introduced species, predation, behavior, interaction, Argentina.

The role of large predators in regulating northern cervids continues to be debated. This function of large predators has to be viewed from a historical-evolutionary angle; how predators affect prey populations in modern human-modified settings can be expected to differ greatly (Berger 1998; Flueck 2000). The evolution of large predators appears to be a systemic functional response as shown by re-evolving ecomorphs among very distant taxonomic groups. Furthermore, ecologically complete northern systems had several predator species with different hunting strategies and several prey species which thus prevented coevolution (Flueck 2000). Parts of Patagonia represent a natural experiment in south-temperate Argentina where European Red Deer *(Cervus elaphus elaphus)* were introduced during the 1920s (Flueck and Smith-Flueck 1993) to areas with native Puma *(Puma concolor).* As the Puma has only occurred in the Americas, these two species have no evolutionary history of sympatry. Furthermore, the native large predators had been extinct for a considerable time in areas of Europe where the European Red Deer originated, and immediate memory of such predators was thus absent.

Hornocker's (1970) work showed that direct observations of attempts by Puma to capture prey was nearly impossible and very few reports have been made previously, mostly stories by hunters (see Robinette et al. 1959). A few additional accounts are based on interpretation of tracks in the snow (Robinette et al. 1959). During many years of studying Puma, Seidensticker et al. (1973: 31) never observed Mule Deer *(Odocoileus hemionus)* or American Elk *(Cervus elaphus nelsoni)* mobbing a Puma, and I found no reference to a cervid fighting off a Puma successfully. Here I report on direct observations of interactions between Puma and European Red Deer.

Study Area

The study area is in the western foothill portion of the province of Neuquén, Argentina (40°58'S, 71°12'W). The topography is primarily mountainous with most features formed by glacial processes. The dominant climate is temperate with main precipitation occurring between April and September. There is an abrupt precipitational gradient from west to east due to the rain shadow effect of the Andes which results in a strongly defined vegetation structure and floristic composition. The study site is between 900 and 1200 m elevation and represents the ecotone between forest and steppe. Patches of forests are characterized by "Ñire" trees *(Nothofagus antarctica)* and "Ciprés" *(Austrocedrus chilensis)* at lower elevations and are replaced by "Lenga" trees *(Nothofagus pumilio)* at higher elevations. Forest patches at lower elevations alternate with wet grasslands ("mallines") with abundant growth of herbaceous plants, whereas at high elevation they are replaced by grass-dominated steppe of "Coirón Amargo" *(Stipa speciosa* var. *major)* and "Coirón Dulce" *(Festuca pallescens),* with variable occurrence of brush species like "Neneo" *(Mulinum spinosum),* "Calafate" *(Berberis* spp.*)* and "Espino Negro" *(Colletia spinosissima).* Riparian areas also contain galleries of small trees like "Radal" *(Lomatia hirsuta),* "Maitén" trees *(Maytenus boaria)* and "Laura" *(Schinus patagonicus).*

Methods and Results

Observations of interactions between European Red Deer and Puma were recorded while stalking alone during field work to collect deer for reproductive studies. Here I report on two such incidents.

On 10 November 1999 at 20:15 h I was returning to camp at a pace faster than stalking as it was getting

late and the deer had not yet descended into the flat open feeding areas below surrounding hills which they use for cover during midday hours. The area I traversed was semi-open with patches of grassland interspersed with some patches of trees like Laura, Radal, and Cypress, typical of the acetone here. There were also patches of brush, predominantly Espino Negro and Calafate. As I was about to pass a stand of Radal, which was approximately 10 m in diameter, I heard the alarm bark of a European Red Deer cow about 20 m away coming from within the stand. I stopped immediately, believing that she must have seen me through the Radal trees, particularly as the same had happened only a short while earlier with a cow which was bedded in a similar tree patch. I thus waited in anticipation that this animal might step out of the trees in curiosity, in which case I would have collected her as well. Looking with binoculars, I could see her move behind the trees and affirmed that she had not yet left.

Suddenly, she barked again and came charging toward me through the patch of trees. Once she was in sight, I saw that she was pursuing an adult Puma, and it was clear that the barking was aimed at the predator and not at me. The Puma stopped shortly after getting out into the open, but as the cow came charging again, the Puma took off and the cow chased the cat around a circular patch of Espino Negro of about 7 m in diameter and 1 m in height. The fast chase took the animals around this bush patch twice, until the Puma apparently stopped out of sight behind the bush. The cow then stopped in front of it and commenced barking again. Finally the cow trotted back toward the patch of trees on the same path where she had come from, only to turn around suddenly and charge toward the patch of bush, stamping in front of it and barking continuously. Four times she repeated this behavioral pattern of trotting away and turning back, but when she finally reduced her aggressiveness and appeared about to retreat, I got ready to collect her. As she turned to enter the trees and was obviously walking away from the scene, I shot, which caused her to run through the tree patch on the same path on which she had originally come out.

After picking up my gear, I came around a bush and went towards the trees. Immediately, I saw the Puma jump out of a tree behind that patch of bush, and follow the deer on the same path through the trees. I then entered the tree patch, having to hunch down to pass through the trail. As I reached the other side, still in a hunched position, I saw the head of a Puma appear at about 15 m from behind a patch of bunch grass; it must have heard me coming through the trees. Looking through the binoculars, I determined it was a cub of the previous year. Still looking through my binoculars, I saw the head of the mother Puma pop up, and without hesitating she approached me to within 10 m. Apparently this was the first she knew of my presence and she began to snarl, which could be clearly heard. After 30 seconds of staring straight at me, she sat down, but kept looking directly at me and snarling periodically. She then appeared to relax in the sense that she would start to look from side to side, blinking slowly, and she was no longer in an alert position.

As the sun had set and I needed to collect information on the cow before dark, I decided after about 5 minutes to move on ahead. I stood up which immediately put the Puma into alert mode. She stood up, started to snarl continuously and stared at me. As I made a first few steps towards her, it became clear that she would rather move back than hold her position, so I continued to move forward. She retreated as much as I would move forward. Approximately 5 m out into the open, I could again see the cub which immediately retreated into the brush upon seeing me. At 15 m from the trees I found the dead cow, while the female Puma stood 10 m away still snarling. As I started to make brisker movements, like taking off the backpack, she retreated farther away and out of sight behind the brush. The thorax of the European Red Deer had already been torn open by the Puma.

The European Red Deer cow was of average body size for this region (Flueck, unpublished data), except girth (116 cm) which was 10% below average. She had absolutely no fat reserves (sternum, rump, omentum, kidney). This was probably due to extreme drought conditions during spring through fall of 1999. Body conditions in fall of 1999 were so low that only 56% of adult females conceived (Flueck 2001) as compared to 100% in previous years. This 14-year-old female had given birth to a calf 1-2 days earlier as evidenced by the still enlarged uterus and the large but hard udder. Furthermore, in the trees I found remains of a calf which had been partially scavenged at least a day earlier; cause of death could not be determined.

The second observation occurred on 17 November 1996, while I was stalking in an area of hilly grassland interspersed with brush. At 18:15 h, I heard a European Red Deer cow bark on the other side of a canyon and shortly after, I observed her running nervously back and forth in a semi circle at a patch of Espino Negro brush, about 5×10 m in area and 1 m tall. Then a calf cried and approximately 5 minutes later cried again. It was obvious that the female had a problem with the calf. Shortly after, I saw an animal body appear from behind the brush patch and enter it. A few minutes later, the female stopped barking and trotted away down the hill. I then went to the spot and as I slowly approached the brush about where the animal had entered earlier, an adult Puma fled crossing the brush patch. Right at the edge was a dead calf which was barely eaten. The Puma had dragged it from some distance when crossing the brush patch. The calf, a male, had body measurements indicating it weighed 11 to 12 kg (Flueck, unpublished data), and several features indicating it was only a few days old (first incisors were out only 4 mm; umbilical scab).

Discussion

Puma in Patagonia are large predators and comparable to or surpass the largest races known from the nearctic (Iriarte et al. 1990). Franklin et al. (1999) reported average weights for female and male Patagonian Puma as 47.5 and 75.8 kg, respectively. Female Puma are known to increase their kill rate several fold when accompanied by cubs and can be expected to increase their aggressiveness. It is thus of interest that a European Red Deer female at the energetically most stressful period right after birthing coupled with nutritional stress from the drought was able to chase a female Puma which had young, up a tree. It indicates that the defense behavior of European Red Deer towards a discovered novel predator like Puma was effective in preventing the death of the mother. In the first case, the cause of the earlier death of the calf is unknown, and as it is common for a cow to remain in the vicinity of a recently born calf after it dies, it explains the aggressive behavior toward the Puma which likely could have prevented predation on the offspring. In the second case, the mother could not prevent predation of her calf by Puma; however, the learning event might enhance the probability that a future offspring might survive. Innate antipredator behavior of introduced European Red Deer therefore, appears successful in assuring adequate numbers of offspring to survive against the native Puma hunting strategy. The loss of exposure to large predators for the founding stock in their original habitat did not prevent the establishment of the founding populations in Patagonia, indicating that rapid learning to defend against Puma must have occurred. Other cervids had become naive to their large predators which became locally extinct, but adapted quickly once these predators reappeared. This was clearly shown for Roe Deer *(Capreolus capreolus),* when Lynx *(Lynx lynx)* were reintroduced (Breitenmoser and Haller 1993), and Moose *(Alces alces)* with offspring after reestablishment of Wolves *(Cants lupus)* and Bears *(Ursus arctos)* (Berger et al. 2001).

On a larger scale, it is also clear that Puma in Patagonia, as the major predator of introduced European Red Deer, are not able to prevent them from increasing numerically (Flueck et al. 2003). Furthermore, as Puma and deer occur across extensive landscapes with no human-related mortality factors for Puma, I postulate that intrinsic mechanisms are responsible for preventing Puma populations from reaching densities where they would exert a control over the deer populations (Flueck 2000). Puma prey frequently on European Red Deer indicating their generalistic and opportunistic feeding behavior. Although about 80% of the natural mortality of adult female deer was due to Puma, annual survival rate of these deer remained high at 91% (Flueck et al. 2004).

These observations support existing studies that the Puma behaves as a generalist predator which can opportunistically adapt to new prey species. Furthermore, they demonstrate that European Red Deer have an ample repertoire of innate antipredator behavior which may partially account for their success as an invasive species.

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Premières mentions de la Couleuvre mince, *Thamnophis sauritus septentrionalis*, au Québec

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Desroches, Jean-François, et Richard Laparé. 2004. Premières mentions de la Couleuvre mince, *Thamnophis sauritus septentrionalis*, au Québec. Canadian Field-Naturalist 118(1): 135-137.

Deux Couleuvres minces, *Thamnophis sauritus septentrionalis*, ont été trouvées les 12 et 13 août 2003, dans le comté de Pontiac en Outaouais, au Québec. Il s'agit des premières mentions de cette espèce dans la province. Des détails concernant les spécimens trouvés et les habitats sont présentés, de même qu'une brève discussion sur la présence de cette espèce au Québec. Trois autres Couleuvres minces ont été trouvées en 2004, dans le même secteur, le même qu'une autre à l'Île-du-Grand-Calumet, à environ 30 km au nord-ouest.

Two Ribbonsnakes, *Thamnophis sauritus septentrionalis*, were found on 12 and 13 of August 2003, in Pontiac County, Outaouais region, in Québec. These are the first records of the species for the province. Details on the specimens and habitats in which they were found are presented, as well as a brief discussion on the presence of Ribbonsnakes in Québec. Three additional Ribbonsnakes were found in 2004, in the same area, and another one on Île-du-Grand-Calumet, about 30 km northwest.

Mots-Clés : Couleuvre mince, *Thamnophis sauritus septentrionalis*, aire de distribution, première mention, habitat, Québec.
Key Words: Northern Ribbon Snake, *Thamnophis sauritus septentrioncilus,* distribution, first record, habitat, Québec.

La Couleuvre mince (*Thamnophis sauritus*) est présente dans une grande partie de l'est de l'Amérique du Nord, de la Floride jusqu'en Ontario (Conant et Collins 1998). Au Canada, elle est représentée par la sous-espèce *T. s. septentrionalis*, laquelle se rencontre dans le sud de l'Ontario et sous forme de population disjointe en Nouvelle-Écosse (Cook 1984). Malgré sa répartition limitrophe au Québec, cette couleuvre n'avait jamais été rapportée dans cette province. *T. s. septentrionalis* mesure au plus 96,5 cm à l'âge adulte et ressemble à première vue à la Couleuvre rayée de l'est (*Thamnophis sirtalis sirtalis*), présentant comme celle-ci un corps foncé marqué de trois rayures longitudinales généralement jaunes. On distingue la Couleuvre mince de la Couleuvre rayée par la position de ses rayures latérales, situées sur les 3^{ième} et 4^{ième} rangées d'écailles du corps, son corps plus élancé et sa queue comparativement plus longue, et l'écaille pâle bien définie devant chaque œil (Cook 1984). La coloration des flancs, sous les rayures latérales, est souvent marron. La Couleuvre mince est considérée menacée en Nouvelle-Écosse et en situation préoccupante en Ontario (COSEPAC 2002*), tandis que la Couleuvre rayée est très commune dans ces provinces tout comme au Québec.

Les 12 et 13 août 2003, dans le cadre d'un travail d'inventaire faunique effectué par le Ministère des Transports du Québec, dans un secteur circonscrit du comté de Pontiac, en Outaouais, nous avons découvert deux spécimens de la Couleuvre mince. Dans les deux cas les couleuvres se trouvaient sur une route de sable et de gravier et ont été aperçues à partir d'un véhicule en mouvement. Le temps était ensoleillé et chaud, avoisinant les 30° Celsius.

Le premier spécimen de la Couleuvre mince a été observé le 12 août à 18h10, sur le chemin Bristol Mines, à 1,2 km à l'ouest de la jonction avec le chemin Pontiac Station (45°29'29"N; 76°20'12"O), à environ 2 km au nord de la rivière des Outaouais. Il s'agissait d'un adulte mort écrasé, mesurant 57,6 cm du museau au cloaque, pour une longueur totale (incluant la queue) de 80,9 cm. Malgré que la couleuvre semblait avoir été tuée plusieurs heures auparavant, il a été facile de l'identifier par la position des rayures latérales et la couleur marron des flancs. Le second individu a été trouvé le 13 août à 16h53, sur un chemin reliant les immenses tas de débris miniers à la rivière des Outaouais (45°28'38"N; 76°20'15"O), à environ 1 km au nord de cette rivière. C'était un subadulte mesurant 29,7 cm du museau au cloaque, pour une longueur totale (incluant la queue) de 45,5 cm. Ce spécimen était vivant et à découvert sur le chemin. Des photographies des deux Couleuvres minces ont été prises par les auteurs. Les spécimens ont été déposés au Musée canadien de la nature (CMNAR 35485, 35486).

L'habitat où furent trouvées les Couleuvres minces est majoritairement forestier avec présence de milieux humides. Dans le premier cas, il s'agit d'une forêt mélangée à dominance de feuillus, où poussent *Acer rubrum*, *Populus grandidentata*, *Populus tremuloides*, *Fraxinus* sp. et *Thuja occidentalis*. En bordure nord du chemin se trouve un étang à Quenouilles (*Typha* sp.) dense d'environ 250 m de longueur par 20 m de largeur. Dans le second cas, il s'agit d'une forêt humide à dominance de feuillus. On y trouve *Betula papyrifera*, *Prunus* sp., *Acer rubrum*, *Populus balsamifera*, *Larix laricina*, *Fraxinus* sp. et *Alnus incana* ssp. *rugosa*. À 40 m au nord, de chaque côté du chemin, un marécage est adjacent à la route. On y retrouve des arbres morts en milieu inondé. Des recherches effectuées dans les habitats avoisinants n'ont pas permis d'observer d'autres Couleuvres minces. Quatre Couleuvres rayées de l'est, soit deux vivantes et deux mortes, ont été observées sur la route durant l'inventaire.

En 2004, trois (3) autres Couleuvres minces adultes ont pu être observées dans le même secteur, qui couvre 18 km^2, et une (1) autre sur l'Île-du-Grand-Calumet, à quelque 30 km au nord-ouest. La première a été trouvée le 9 juin en bordure d'un étang à quenouilles près d'un chemin de terre (45°29'10"N; 76°20'56"O). La seconde a été observée le 14 juin dans une flaque d'eau en assèchement, bordée de saules (*Salix* sp.), à 10 m de la forêt (45°29'40"N; 76°22'00"O). La troisième a été vue le 12 juillet sur une hutte de Castors (*Castor canadensis*) (45°31'51"N; 76°18'43"O). Le spécimen de l'Île-du-Grand-Calumet a été trouvé le 11 août sure une hutte de Castors (45°41'12"N; 76°38'31"O). Des photographies des Couleuvres minces ont été prises par l'un des auteurs (JFD).

La présence de la Couleuvre mince au Québec n'est pas surprenante puisqu'on la retrouve en Ontario à proximité, de l'autre côté de la rivière des Outaouais (Tobias et Evans 1979; Cook 1981; Oldham et Weller 2000*). Il est plutôt curieux qu'elle n'ait pas été rapportée plus tôt dans la province. Il s'agit bien sûr d'une région peu habitée et sous-inventoriée par les biologistes, mais plusieurs inventaires spécifiques y ont été réalisés notamment pour les tortues. Il apparaît possible que sa ressemblance avec la Couleuvre rayée de l'est, très commune dans la région, ait contribué à la garder dans l'anonymat durant toute cette période.

La Couleuvre mince devient donc la 38^{ième} espèce de l'herpétofaune au Québec et la 8^{ième} en ce qui concerne les couleuvres. La liste des couleuvres du Québec comportait sept (7) espèces depuis 1927, année où la Couleuvre brune (*Storeria dekayi*) fut découverte à Montréal (voir les données détaillées dans : Bider et Matte 1991). Les additions récentes à l'herpétofaune québécoise concernent les autres groupes (anoures, urodèles et tortues). Ce sont la Salamandre sombre des montagnes (*Desmognathus ochrophaeus*), découverte au Québec en 1988 (Alvo et Bonin 2003), la Tortue musquée (*Sternotherus odoratus*) en 1989 (Chabot et St-Hilaire 1991) et la Rainette faux-grillon boréale (*Pseudacris maculata*) en 1991 (Bider et Matte 1994). L'addition de la Couleuvre mince à la liste des reptiles du Québec revêt une importance particulière puisqu'il s'agit sans aucun doute d'une espèce très rare dans la province et qu'elle est déjà considérée en situation précaire en Ontario et menacée en Nouvelle-Écosse. Des inventaires supplémentaires seront nécessaires afin de préciser sa répartition et son statut au Québec. Finalement, cette couleuvre vient probablement clore la liste de l'herpétofaune du Québec, si l'on se fie à la répartition actuellement connue des espèces.

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Book Reviews

Zoology

Amphibian Decline: An Integrated Analysis of Multiple Stressor Effects

Edited by Greg Linder, Sherry K. Krest, Donald W. Sparling. 2003. SETAC North America, 1010 North 12th Avenue, Pensacola, Florida 32501-3367 USA. xxi + 345 pages. U.S.$98 Cloth.

This volume contains presentations at the Workshop on the Global Decline of Amphibian Populations sponsored jointly by the Society of Environmental Toxicology and Chemistry (SETAC) and The Johnson Foundation 1-23 August 2001 at Racine, Wisconsin. Fifteen papers are included as 10 chapters, one with A-B and another with A-E designations for no apparent reason.

Canadian data and perspective on the problem of declines are not neglected. Of the 35 contributing authors listed, 31 are from the United States but four are Canadian: Christine Bishop (Canadian Wildlife Service, Delta, British Columbia), David Cunnington ("freelance", Victoria, British Columbia), Martin Ouellet (Redpath Museum, McGill University, Montreal, Quebec), Bruce D. Pauli (Canadian Wildlife Service, Hull, Quebec). Ouellet is one of nine coauthors of Chapter 6 "Biotic Factors in Amphibian Population Declines", and Bishop, Cunnington, and Pauli are half of the six coauthors of Chapter 7 "Physical Habitat and Its Alteration: A Common Ground for Exposure to Environmental Stressors".

None of the individual chapters is a particularly easy read and their results or conclusions often are neither clear-cut nor universal in their application. However, collectively, they effectively and repeatedly bring out the complications in separating climatic, chemical pollutant, and biotic pressures, many of which doubtlessly combine to produce documented or supposed losses or declines. The texts are heavily laden with flow and modelling in 18 figure diagrams, 18 tables, 5 matrices and even two "test boxes" to visually present concepts and consequences. Each chapter has its own bibliography.

The concluding summary chapter effectively stresses the continuing, unresolved nature of the problems, but, in an inevitable rather self-congratulatory manner, arrives at the conclusion that this workshop was vital to promoting a much-needed exchange of expertise on various aspects of real and potential amphibian declines and that it has created a network for further discussion and exchange. Although one could argue that this was happening anyway, the workshop did usefully focus discussions and the book spreads the state of knowledge. It is useful both for what research has been done and for what future approaches might be productive. One can hardly disagree with the fundamental conclusion that further sharing of information as it develops will be essential to adequately defining future measures. If, eventually, there ever will be effective conservation of the world amphibian fauna it will depend on a better understanding of the causes and reality of the declines.

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Birds of Africa: From Seabirds to Seed-eaters

By Chris and Tilde Stuart. 1999. MIT Press, Five Cambridge Center, Cambridge, Massachusetts, USA. 176 pages. U.S. $29.95 Cloth.

This is an attractive book that appears to be intended as a typical "coffee table" volume. It is large in size (22 × 28 cm). profusely illustrated and very well laid out, with between 2 and 9 illustrations on each two-page spread. The plates themselves range from full page to quite tiny (under 4 cm^2).

The text is presented in 12 chapters plus an introduction, species list, and index. Each chapter is devoted to a group of bird families with some feature in common. Thus we have "Birds of the Oceans", "Birds of Inland Waters and the Coastline", "LBJS", and so on. Chapters then deal with each family in turn (grouped in the sequence of their common names), giving the number of species that occur in Africa together with a brief account of the family characteristics, and something about a sampling of the species. Occasionally there are boxes which treat a particular topic in some detail; for example, "The Dilemma of Island Birds".

The main body of the text enlivens the chronicle of numbers and species descriptions by concentrating on interesting anecdotes and "gee whiz" facts about the species under discussion. The authors are African and obviously have had considerable experience with the continent's bird life. On the whole their statements seem accurate, although I was unable to check some of them, but some are incorrect. For example, Great Skua does not breed in the Southern Hemisphere, Kelp

Gull is not an African endemic, and the Australian Ibis is not conspecific with the Sacred Ibis.

For me this book has some rather irritating problems that in sum seriously detract from its interest. Overall there is a lack of cohesion, mainly resulting from the organization of the text. The arbitrary chapter groupings inevitably run into families that do not quite fit the category, or fit into more than one. I would be inclined to place gulls and terns in the coastal waterbird chapter, lots of the "Seed-eaters" are classic LBJ's, and "Terrestrial Birds" results in a strange collection of species with Pittas following Ostrich. This is accentuated by the layout within the chapters, with (for example) "Avocets and Stilts" at the beginning of Chapter 3, "Oystercatchers" and "Plovers and lapwings" in the middle separated by Pelicans, and the "Waders or shorebirds" at the end. True, the systematic list at the end is in order, but this does little to balance the sense of randomness that one gets from the text itself.

Probably the authors would point out approaches of this kind are not unusual for books of the genre: they are not, after all, basic reference texts. Unfortunately, attractive though the layout is, there are problems with the plates as well. In many cases the tinier illustrations are difficult to see properly, many of the poses are poor, and the selection of subjects pictured leaves something to be desired. Opening the book at random I find pp. 130-1 show two different pictures of Arrow-marked Babblers, one of the Southern Pied Babbler, and one of a Wallcreeper. The latter only occurs as a vagrant in North Africa, and the plate shows little of this species' remarkable wing pattern, so it simply looks like a gray bird. Africa does have a creeper species, and the text on these pages also includes the broadbills (Eurylaimidae). These species are not illustrated at all.

In summary, this book brings together a large number of photographs of African birds, some of them very good, together with a compilation of interesting facts and anecdotes on African bird families. My quarrels with content are really irrelevant if this is all you are looking for, or if you find this book attractive enough in itself to buy. Those who desire a thorough overview of the African avifauna should look elsewhere.

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The Firefly Encyclopedia of Birds

Edited by Christopher Perrins. 2003. Firefly Books Ltd., 3680 Victoria Park Avenue, Toronto, Ontario M2H 3K1 Canada. 656 pages. U.S.$59.95.

Naturalists across the continent strive to ever increase their knowledge of local wildlife, and all love to hear about wildlife from other localities. Birdwatchers, for example, can become very knowledgeable about their local species, and the zealous ones will even study species from other areas within the same country, continent or even from around the world. But the vast array of bird species is overwhelming, and it takes a serious encyclopedia to pull them all together. Luckily for us, *The Firefly Encyclopedia of Birds* edited by Christopher Perrins is just what we needed – a good collection of text and photos of the birds of the world all in one volume. Nicely presented with tons of sharp photos illustrating everything from specific behaviours to simply jaw-dropping "coolness" (including several underwater pictures such as common murres on page 280-281, common kingfisher on page 368, and American dipper on page 521), the book is backed up by solid text summarizing well the basic tenets of ornithology. Moreover, each chapter focuses on a bird family (the large number of species precludes a species-by-species analysis), and is accompanied by a "factfile". This sidebar summary provides a general description of size and habits, as well as a broad distribution map and my favorite, a visual comparison of bird size to a human.

The book also details several interesting specific behaviors, such as pigeon homing (pages 294-295), or the nest parasitism of Cuckoos (pages 316-317), but nothing on the degredation of the tundra by Snow Geese, a topic of high importance and actuality in North America. It also discusses extinct birds such as the Elephant Bird (page 21), the Dodo (page 291), and a short paragraph on the Passenger Pigeon (page 293). The book provides a fantastic introduction to birds from all around the world, is extremely well presented, very reasonably priced ($75.00 CAN, hardbound), and constitutes a worthy, if not essential, addition to the library of all bird enthusiasts.

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Birds of Belize

By H. Lee Jones. 2004. University of Texas Press, P.O. Box 7819, Austin, Texas 78713-7819 USA. x + 444 pages. U.S.$60.00 Cloth, U.S.$34.95 paperback.

This first edition covers the 574 species of birds recorded in the old British colony of Honduras, and now called Belize. Virtually all the birds are shown in colour plates, with accompanying text and 234 range maps. The book has a brief introduction to the biogeography and climate of Belize and a how-to-use chapter. This latter is very important because it explains how the author has chosen to organize the book and select the "common" names, as well as the names in Maya, Spanish and the aboriginal language. The range maps, at the back of the book, mostly cover the resident species and are large enough to be a useful guide.

The text is precise and clear and contains much useful information. For example, the call of the Northern Potoo is described in terms that should enable anyone to recognize it. This is the key characteristic in separating the Common from the Northern Potoo. Another good example is the description of the Double-toothed kites, explaining the "Distinctive puffy white undertail coverts that spread to the sides of the rump ...." This is a very good field character and this description captures it well.

The artwork is by Dana Gardiner, the same artist that illustrated the *Birds of Costa Rica* by Stiles and Skutch. I found his style a little stiff, giving the birds a flat appearance and missing something of their jizz. These new renderings, while similar to those in Birds of Costa Rica, are an improvement. The Wedge-billed Woodcreeper illustration more clearly depicts its remarkable tail. The Emerald Toucanet is the correct subspecies, *Aulacorhynchus prasinus prasinus*, showing a white throat. However, I did have difficulties with some plates, but I think this relates more to the printing than the artwork. For example, the depiction of Cedar Waxwing is far too intense and the elaenias are much too dark. The depiction of the Violet Sabrewing is deep blue. I have never seen one in the field that did not look violet (as described accurately in the text and depicted accurately in *Birds of Costa Rica*) under any light conditions. In particular I checked the depictions of Scaly-breasted Hummingbird (poorly done in *Birds of Costa Rica*) and it is better, but I still think a novice would have trouble in the field using the plate for identification purposes.

The nomenclature is fairly standard. The author retains Rock Dove for *Columba livia* (instead of the new "Rock Pigeon" – thereby reducing confusion with the orange-brown Rock Pigeon of South Africa, *Columba guinea*). I had to use the scientific name of *Phaethornis longirostris* to be sure the author's Long-billed Hermit was the same as Stiles and Skutch's (Western) Long-tailed Hermit. I am still confused as to the status and distribution of Passerini's and Cherrie's Tanager (a recent split of Scarlet-rumped Tanager). Only Paserrini's Tanager is listed for Belize, which I believe is correct.

This guide is just under 6" × 9" × 1.25" (15 × 22 × 3 cm) and is too large for the average pocket. Although I have some reservations, I still think this book will make a useful field guide, especially if you use the text in conjunction with the plates. This book represents a good stride forward in literature for this section of the Americas. If it is to be used in the field I would be tempted to take along a Mexican guide as a second reference.

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Herpetology: Third Edition

By F. Harvey Pough, Robin M. Andrews, John E. Cadle, Martha L. Crump, Alan H. Savitsky and Kentwood D. Wells. 2004. Pearson Prentice Hall, Upper Saddle River, New Jersey, USA. ix + 726 pages. U.S.$93.

In the preface to this edition of *Herpetology*, the authors state, "understanding amphibians and reptiles as organisms requires a perspective that integrates their morphology, physiology, behavior, and ecology and places that information in a phylogenetic context." The authors have done a commendable job at fulfilling this daunting task.

The text book is divided into four parts and each part is subdivided into chapters. Part one (What are amphibians and reptiles?) explores the field of herpetology, the place of amphibians and reptiles in vertebrate evolution, systematics and diversity of amphibians and reptiles, and biogeography. Part two (How do they work?) has chapters on temperature, energetics, reproduction, locomotion and feeding. Part three (What do they do?) covers movements, communication, mating systems, diets and species assemblages. The fourth part (What are their prospects for survival?) discusses conservation of amphibians and reptiles in a single chapter.

How does this edition differ from previous editions? The second edition was published in 2001 and hence this edition includes many references to recent publications. There is also a greater emphasis on phylogenetic analyses, particularly in the early chapters on systematics. This edition also features colour photographs and colour distribution maps for the families of amphibians and reptiles. The colour maps do not really add much, but the colour photographs are effective. A chapter on biogeography is one of the biggest

changes in content in this edition. The authors have also wisely split the chapter on reproduction into two chapters, one each for amphibians and reptiles. The section on conservation has also been expanded, reflecting the growing concern over many species in both groups.

It is hard to find much wrong with this exhaustive examination of the current state of herpetology. The one conspicuous absence is a glossary, something that would surely be important in any comprehensive textbook such as this. Overall, the combined talents of six experts with diverse research interests is hard to beat. After two previous editions, the authors have resolved most of the inevitable errors and contradictions resulting from integrating the writing of so many people. It is hard to imagine a better single volume overview of these fascinating creatures.

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Lizards: Windows to the Evolution of Diversity

By Eric R. Pianka and Laurie J. Vitt. 2003. University of California Press, 2120 Berkeley Way, Berkeley, California, USA. xii + 333 pages. U.S.$45 Cloth.

Individually, each author of this volume has more than 30 years of lizard study in various areas of the world. These include the southwestern (both) and southeastern (Vitt) United States, as well as Africa and Australia (Pianka) and Central and South America (Vitt). Each has included a personalized capsule biography of his background and interests, each emphasizing what first attracted him to lizards.

This book is number 5 in the University of California Press series *Organisms and Environments*. The introduction explains that it grew from a resolve by authors 10 years ago. At that time, while working on a third lizard ecology symposium volume, they envisioned production of a comprehensive semi-popular book on the group. In a review of the earlier work, the 1994 *Lizard Ecology: Historical and Experimental Perspectives*, Robert W. Murphy (1995. *The Canadian Field-Naturalist* 109(1): 135-136), while generally praising its standards of "highest academic acumen", thought it "not necessarily well suited for bedside reading by the merely curious. And it will not make a good coffee table book as there are no high-gloss photographs".

The latter criticism has been particularly well responded to in the new volume. It is not only coffee-table size in design (28.6 × 22.5 cm) but has the requisite high-gloss photographs scattered throughout. These, often emphasizing activity or displays, splendidly illustrate the diversity of behaviour as well as form and pattern for a well-chosen variety of lizards. There are also a scattering of graphs, tables, diagrams, and maps to illustrate particular points. Included are evolutionary relationships between groups of lizards, biotic and abiotic factors affecting a lizard's well-being, avenue of heat gain and loss for a diurnal basking lizard, comparison of mean percent use of the seven most important prey categories by neotropical and desert lizards, prey size vs lizard size, independent evolution of body type in Jamaica and Puerto Rico, and population size for species of land iguanas on islands of the Caribbean, to choose a few at random.

The introduction raises the question: "what good are lizards?" This is first summarily dismissed with a curt retort, emphasizing the authors' abhorrence of anthropocentrism, "what good are people?". Subsequently, the instructive value of lizards in relation to the ecosystem is attributed to their multitude of forms and the variety of habitats they have successfully occupied. They can thus effectively serve as "model" organisms for broad understanding of ecology and the diversity of animal life, a theme also emphasized in the earlier symposium volumes.

Following the introduction are three major parts with seven, six, and two sections: (1) Lizard Lifestyles: Evolutionary history and phylogeny, Getting around in a complex world, Lizards as predators, Escaping predators, Social behavior, Reproduction and life history, and Reflections of a real world; (2) Lizard Diversity: Iguanians, From Geckos to Blind Lizards, From Racerunners to Night Lizards, Skinks, From Girdled Lizards to Knob-scaled Lizards, Monsters and Dragons of the Lizard World; (3) Synthesis: Historical perspective, Lizards and humans. In the initial section it is pointed out that as a group "lizards" is paraphyletic due to excluding the snakes. The latter are omitted as they traditionally have been treated as a separate equal group, though now recognized in contemporary clarification as just an offshot within varanoid lizards (as shown in Figure 1.4, page 16).

The major partitions are followed by a four-page Taxonomic Summary (with number of species in each family or subfamily (if it has been subdivided) listing all included genera). The species totals are given (by major subdivisions) as Iguania 1340+; Scleroglossa: Gekkota 973+, Incertae sedis 151+; Autarchoglossa (excluding snakes but inclusive of Scincomorpha: Lacertoidea, Scincoidea: Anguimorpha [including Varoidea]) 1745+; or collectively over 4200. The book concludes with a three-page Glossary (abiotic to zygodactyly), an 18-page references section, and a nine-page index.

Throughout, the book is a pleasant mix of formal and informal styles. Scientific discussions have shuffled among them separate blocks of personal observations, often field experiences of one or the other author. As stated (page 7) "Throughout this book, we continu-

ally return to questions we asked as children in an attempt to encourage readers to open their minds and to ask questions". This responds splendidly to the earlier reviewer's wish for a text "well suited for bedside reading by the merely curious". Unfortunately, the large coffee table format and the glossy reflective pages make it awkward to handle in bed and read by bedside light. But as an up-to date comprehensive survey of world lizards it has no equal. It provides great perspective of their global importance, a fact strictly Canadian naturalists, who have only six species belonging three families of non-snake lizards to observe in their entire country, have little first-hand chance to appreciate.

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Raptors of Western North America

Brian K. Wheeler. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 544 pages, 625 colour photographs, 56 maps, U.S.$49.50 Cloth

This book is both a tour de force and a labour of love, and the immediate new standard for diurnal raptors in western North America. Raptors are known for their variable plumages, and standard field guides cannot cover the almost infinite permutations and combinations; hence, erroneous identifications are legion among regular birders, and even among raptor enthusiasts. No full-time museum, government or university employee has dared to undertake a book of this scope; it is all the more astounding that this hiatus was filled by a truck driver. More incredibly, Wheeler has developed the skills to take the great majority of the photographs himself. His experience and enthusiasm are evident throughout. He has reviewed the literature carefully and has been given access to unpublished information from graduate students and others; for example, numbers of Northern Goshawk and Bald Eagle territories are provided for each state. There are nearly two pages about the ten-year cycle of the Snowshoe Hare and Northern Goshawk, absent from most other raptor books; goshawks peaked at Duluth, Minnesota, during the irruption years of 1972, 1982, 1992 and 2001, mostly adults fleeing the mixed forest following each Snowshoe Hare crash.

Excellent historical accounts include notably that for the California Condor. There are four excellent glossaries: general, anatomy and feather, plumage and molt, and displays. The detailed descriptions of raptor plumages are unprecedented and unequalled. Fortunately, important points are highlighted in bold, making the tedious mass of description more user-friendly.

Readers will be amazed by the remarkable variability of plumage in species such as the Ferruginous Hawk (25 photos), Rough-legged Hawk (39 photos), and Swainson's Hawk (40 photos), and especially the Red-tailed Hawk; variants within the latter species are depicted in 82 photographs, 22 pages of verbal description and six maps.

John Economidy has contributed clear, accurate range maps for 33 species, six for the Red-tailed Hawk alone. The maps are incredibly precise, but I noticed four minor errors for Saskatchewan species: the Big Muddy area of Saskatchewan is omitted from the Golden Eagle; the two southern year-round localities for Bald Eagle should be winter only; recent small southerly extensions of Osprey and Northern Goshawk ranges are not shown; the two races of the Merlin are not known to overlap between Saskatoon and Prince Albert. The maps also give no indication of range changes in the past.

Since this veritable encyclopaedia of western raptors (an eastern counterpart became available simultaneously) is too heavy for most backpacks and too large for most glove compartments, most of us will use it as a reference in our libraries. One hesitates to quibble about the first edition of such a superb book. Yet the title is misleading, since owls are not included; inclusion of the term "diurnal" would have made the title more accurate. The ground squirrel has not lost half its range in western Canada, as it has in Idaho (page 521). Use of dieldrin, not DDT, was coincident with the early 1960s crash of the Merlin on the Canadian prairies (page 447). Use of "very uncommon" sometimes contradicts his definitions in the introduction. I detected few errors, but "verses" in place of "versus" jarred me (page 199). Wheeler has been involved in two previous hawk identification books, each excellent, each with William S. Clark as co-author. The first was *Hawks* in the Peterson Field Guide series and the second, *A Photographic Guide to North American Raptors*. For most general birders, either would suffice, although many plumages are omitted from both of the smaller books. If you are a raptor aficionado, don't let the cost of the new book deter you; the 603 colour photographs easily justify the price and the 33 colour maps are more detailed than anything previously available.

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Raptors of Eastern North America

By B. Wheeler. 2002. Princeton University Press, 41 Williams Street, Princeton, New Jersey, USA. xv + 439 pages, U.S.$45.00 Cloth

Let me begin by saying this is a wonderful book. It gives a very detailed account of all the 26 full species of hawks, eagles and falcons occurring in eastern North America. It is profusely illustrated with extremely good, frame-filling, crisply focused photographs. These range from nine photographs for the Short-tailed Hawk to an incredible 82 of the Red-tailed Hawk. The text, despite its somewhat clipped English, is very informative. All of the known and recognizable sub-species are included, both in the text and, where valid, in the photographs. The level of detail given in the plumage descriptions is far greater than in any other book I have read. The range maps are sized as appropriate to the species they cover. For widespread birds the map depicts all of eastern North America. However, larger scale maps are used for such localized birds as Florida's Snail Kite.

This is easily the best photographic-style guide I have seen and is a real testament to the author's dedication. Thus it is the most thorough guide to this group of North American birds you can purchase. The full-color, superb photographs alone are worth the price of the book. The author has included all the plumages, races, and colour variations possible. They cover a bewildering range of plumages for species that can be annoyingly difficult to identify in the field. This makes it an almost essential book for serious bird-watchers and ornithologists and a great resource for beginners trying to grapple with the plumage variability. I do not consider this book to be a portable field guide, but a reference work. It is a little too large and heavy (due to the thick, high-quality paper). More important, this would be too precious a book to risk damaging in the field.

I searched through for errors and did not notice any. In fact, I was impressed by the thoroughness of the coverage. For example, the author has correctly included the spotty northern locations for Osprey in Labrador.

However, I do have one major problem with this volume. It is a companion volume to *Raptors of Western North America*, a slightly larger book covering 33 species. Thus, there are 23 species common to each book. The species accounts and photograph are almost identical, except that the range maps are different. This means there is a good deal of unnecessary repetition. I can only assume that some marketing guru felt that two versions would sell better than one. Combining into one book would increase the size from 544 to about 600 pages to allow for the text for two additional species and the eastern range maps for all species (plus a little added to the index.). This would presumably increase the price to around U.S.$60. Each book is a worthwhile purchase on its own. If you buy the western book you will miss the accounts for Snail Kite only. If you buy the eastern guide you will lose the accounts for nine western raptors. If you buy both you will get more than 75% repetition, in essence wasting U.S.$30, to get the coverage of one extra species plus the relevant range maps. If you can afford only one book, buy the western guide.

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Turtles and Tortoises

By Vincenzo Ferri. 2002. Firefly Books Ltd., 3680 Victoria Park Avenue, Toronto, Ontario M2H 3K1 Canada. 255 pages. $24.95

This compact little book is a translation of the 1999 Italian publication, *Tutto Tartarughe e Testuggini*. It can best be thought of as a photographic guide to 152 species of turtles – roughly half of the species alive today.

The book opens with an introduction covering the biology, evolution, classification and conservation of turtles. The bulk of the book is occupied by species accounts. The species accounts are grouped geographically into oceans (sea turtles) and six terrestrial areas: Palearctic, Afrotropical, Oriental, Nearctic, Neotropical and Australian regions. There are 152 numbered species accounts and additional unnumbered accounts sprinkled throughout the book. It is unclear why some species accounts are not numbered, although the unnumbered accounts do not have a colour photo (they do have a colour illustration) or map. The species accounts are brief (some less than 100 words), with most ranging from half a page to a full page in length. Each account has standardized subheadings: Family, Distribution and habitat, and Characteristics. Some of the accounts also have a "Situation" subheading describing conservation issues.

Perhaps because it is a translation, this book is plagued with errors. Translation-type errors include some unusual common names. For example, the Bog Turtle (*Clemmys muhlenbergii*; now *Glyptemys muhlenbergii*) is called Muhlenberg's Turtle. That may well be the English equivalent of the Italian common name, but that term is not used in North America. Similarly, the Painted Turtle (*Chrysemys picta*) is referred to as the Painted Tortoise. In addition, the genus is misspelled "Chrysemis." Errors in content also abound. The author asserts that *Eunotosaurus* is the earliest known ancestor of turtles, yet this theory is no longer

widely accepted. It is also stated that some turtles can hibernate for 2-3 months, a gross understatement of the 6+ months that some turtles spend in hibernation.

The species accounts are also fraught with errors or misleading information. For some North American species, the author lists individual U.S. states where the species is present, yet the list is rarely complete. The Blanding's Turtle (*Emydoidea blandingii*) account omits any mention in the text or the map of the Nova Scotia population. The author accepts the Mississippi Map Turtle (*Graptemys pseudogeographica kohni*) as a species (*G. kohni*), even though the species account suggests it is a subspecies. There are also some curious omissions. There are six species accounts for members of the genus *Graptemys* yet the most wide-ranging species, the Northern Map Turtle (*G. geographica*) is not included. Overall, one has the sense that the text was assembled quickly, or by using outdated reference materials, and that it was not reviewed by a scientific expert. Enjoy the photos but don't believe everything you read.

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What Good are Bugs? Insects in the Web of Life

By Gilbert Waldbauer. 2003. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts, USA. 384 pages. U.S.$29.95

Waldbauer has written several other popular books about insects, and these have been met with high acclaim; I have not read those tomes, and so see his most recent work with unbiased eyes.

What good are bugs? focuses on the interactions insects have with other animals and plants, both living and dead. Several chapters in each category illustrate the myriad ways in which insects, wittingly or unwittingly, are key to earth's ecosystems as we know them today. Topics range from seed dispersal to recycling dead animals and the control of animal and plant populations. Truly, the scope of this book is close to all-encompassing, and is written in a style that will not be condescending to the informed naturalist or biologist, but will be readily consumable by the budding naturalist, too.

There are a few factual problems, as well as some opinions that are more typical of the entomophobic component of the public, that were surprising and disappointing to see in a book which promotes insects. Several times Waldbauer has insects "attacking" plants, when he really means "feeding on" plants. No one would ever say that deer or rabbit attack plants, it's no different with insects; they are just feeding on the plants, a point that naturalists, biologists, and surely this author should understand. "Attacking plants" is an expression used by certain people or industries to incite action, to justify eradication, to gain sympathy from the uninformed, and should itself be eradicated from our vocabulary.

The book ends with a chapter-by-chapter listing of selected readings. I like this method of listing references since the reader can readily choose among works only in the topic of interest. Overall, this is a book well worth having.

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Belugas in the North Atlantic and the Russian Arctic

Edited by M.P. Heide-Jørgensen, Ø.Wiig, and D. G. Pike. 2002. NAMMCO Science Publication 4, The North Atlantic Marine Mammal Commission, Polar Continental Centre, N-9296, Tromso, Norway NOK 150. 270 pages.

The greater part of this symposium is devoted to those beluga whales that migrate through Baffin Bay and Davis Strait between the eastern part of the Canadian Arctic and West Greenland, and are difficult to follow across the deep water (and impossible in the dark season). Moreover, it is a difficult publication to review because it represents "work in progress", the results of which are not yet fully understood by the authors themselves. Three main techniques of study were (1) mitochondrial molecular genetics from tissue sampling of restrained or dead animals; (2) aerial photographic surveys; (3) tracking individuals by means of satellite radio tags attached to implants in the dorsal ridge of temporarily trapped belugas. The results are too tentative to summarize easily. Many groups of belugas observed in summer in arctic estuaries are essentially matrilines, that is, adult females with young animals of both sexes, while most adult males may move independently in different ways. There is also the practical concern that catches of belugas at southwest Greenland, where there is most open water and the largest catching boats, appear to exceed recruitment. The exact area from which these animals come is unknown.

After this it is a pleasure to move on to simpler studies! An overall survey of Russian and Siberian arctic waters from the mainland was carried out in the course of ice studies for belugas, narwhals and Greenland or Bowhead whales, plus the few Grey whales that enter the Arctic Ocean. There is now little hunting for them in this half of the Arctic.

Lastly, a summary is given of up-to-date knowledge of the numerical status of belugas that inhabit, year-round, the less than 200 linear km of the St. Lawrence

estuary in Quebec. This is the most biologically productive part because of year-round vertical water mixing. Aerial photographic surveys of numbers are therefore simple to carry out, but it is necessary to measure the percent of animals diving too deeply to be registered visually or by camera form the air. M. C. S. Kingsley and team did this using a helicopter hovering at an altitude that did not disturb the animals. The correction factor turned out to be more than two, so that estimates of numbers needed to be more than doubled, giving a total of more than 1200. Moreover, a series of estimates made since even casual hunting ended, ca. 1979, up to the last recorded survey in 1998, showed that the population has been growing slowly.

I add to this review some more recent information that several belugas, including one radio-tracked animal, moved in autumn 2002 from SE Hudson Bay to off Nain, Labrador (D. W. Doidge, personal communication), showing that therefore some animals "bleed" from the Arctic into the Labrador Current. These must be the source of infrequent but not rare animals which reach the east coast of Newfoundland (Curren and Lien. 1998. *Canadian Field-Naturalist* 112(1): 28-31). These were noted by Kingsley in this book, but have not been tracked further. Animals coming from the St. Lawrence estuary are also known to "bleed" into waters around the Maritime Provinces as far as the Bay of Fundy and even to New Jersey (various references). It therefore seems very unlikely that the St. Lawrence population is isolated genetically from the main Arctic population of belugas.

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The Firefly Encyclopedia of Insects and Spiders

Edited by Christopher O'Toole. 2002. Firefly Books Ltd., Willowdale, Ontario

I will first state my biases and say that I'm not a big fan of encyclopaedias. Having got that out of the way, I must say this book was engaging, excellently laid out, and an absolute joy to read. The photographs ranged from very good to excellent to amazing. The full-frame images of even small insects startled me with their clarity. Diagrams were liberally used, effective, and also of exceedingly high quality. Each chapter was written by one or more experts, and I enjoyed reading them all. The majority of insect orders are covered, as are most of the arachnids (not just the spiders as the title alludes).

Although this book could not serve as a university text in entomology, if I were to offer a bug course at the high school level, I would use this book. I have seen many entomology texts, and none are as visually appealing as this book. This book would not substitute for a field guide because of its size, but the quality of the text, illustrations and photos far exceeds any of the field guides I've used.

Interspersed with the taxonomic accounts which dominate the book were photo stories, fact files and special features. These articles ranged from less than a page to two pages and provided a different tangent on insect and arachnid life. As with the rest of this book, these articles were well done.

The weaknesses were very few. My underlying feeling was that I couldn't be certain as to the intended audience. The wording is usually so straightforward that children from eight or nine years old should be able to read it; however, technical terminology creeps in now and again, and would likely give those same early readers quite a pause. For the most part, the technical lingo is kept to a minimum, and is often isolated from the main text in sidebars. This book is billed as an encyclopaedia, and the publishers I think were striving to market the book to a wide audience.

My only quibble about the actual content was that the minor taxa were mentioned only in a list alongside the more dominant taxa, and not given their own words or photographs to describe them. I realize that no book that features the ricinuleids more than the beetles will ever sell, especially to the general public, but a photograph and a quarter page or so of text for each of these minor taxa would have been appropriate. Overall though, a great reference book, with wonderful visual appeal.

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BOTANY

Biotic Forest Communities of Ontario

By Norman Duncan Martin and Norma M. Martin. 2003. Commonwealth Research. Belleville, Ontario, Canada. 195 pages. $10.00 paper.

Martin and Martin set out to identify the basic forest communities of Ontario, describe their biotic composition, and consider the successional relationships among them. While they draw on an impressive amount of personal research and a broad literature survey, the book lacks focus and therefore may have a limited value to a general audience.

A fundamental component of any scientific study is that the work must be repeatable. When presenting study results it is therefore essential that the methods are clearly laid out. This is not the case here. The reader is informed that the authors tallied vegetation in transects in various types of forest. A single map of transect locations is provided, with numerous examples of data sheets. No details are provided to explain the selection of transect locations nor which aspects of the vegetation were sampled or how. There is also no explanation of the analysis itself, other than to acknowledge the influence of the "schools of interpretation" of Clements, Curtis, Hills, Whittaker and others. These were indeed important workers in this field, but listing their names doesn't allow the reader to critically examine the results of the current study.

The bulk of the book is devoted to descriptions and tables illustrating the ten forest community types identified by the authors. There are interesting observations here, but the sheer quantity of poorly organized data makes it difficult to appreciate. Most of the data is presented as tables showing various measures of abundance in selected samples. The only graph prepared by the authors is labelled as showing a "discernable pattern with characteristic variability". The discernable patterns are lines overlaid on the plotted points without any statistical support. This would not be acceptable in an undergraduate ecology class, let alone a scholarly thesis.

It is unfortunate that the authors make no reference to Lee et al. (1998), which has become the standard forest classification system for Ontario. It may be interesting to contrast the ecological land classification (ELC) of Lee et al. with Martin and Martin's forest communities. If their data could be used to refine or correct the ELC system it would be far more useful than it is as a stand-alone study.

The most interesting part of this book is the relationship between forest types and their fauna. The authors have collated a great deal of their own data as well as data from published and unpublished sources. A more thoughtful analysis of this aspect of their study might produce a more enduring contribution to the study of forest ecology in Ontario.

Literature Cited

Lee, H., W. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig, and **S. McMurray.** 1998. Ecological land classification for Southern Ontario: first approximation and its application. Ontario Ministry of Natural Resources, Southcentral Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02.

TYLER SMITH

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Les champignons des arbres de l'est de l'Amerique du Nord

By Bruno Boulet. 2003. Les Publications du Québec, Sainte-Foy, Quebec, Canada. 727 pages. $49.95

The author and a number of colleagues have invested a considerable effort to produce this detailed treatise on the principal wood-inhabiting fungi (mostly polypores) of eastern North America. The 19 × 24 cm, hardcover book is heavy but the binding is robust. The book contains nearly 500 color pictures, typically 6 or 7 on a page, of very good quality.

There are three principal sections. First there is a brief commentary on the vegetation of Quebec, especially in relation to the geographic and host distribution of the wood-inhabiting fungi. Then 118 pages are devoted to a discussion of the state of our knowledge of the polypores, including their medicinal properties, edibility, and traditional and commercial uses. The role of these fungi as forest pathogens and their influence on the management of forests are reviewed and various tree defects caused by these fungi are depicted in color.

The second section of the book introduces the reader to the taxonomy, nomenclature and classification of the polypores, as well as their distinctive macroscopic and microscopic features. The latter are in some instances essential in naming specimens. This section concludes with an explanation of the most common means of identifying and naming a specimen, i.e., the botanical dichotomous key, and a key including over 400 taxa. About 120 of the 400 are mushrooms that are briefly described in the key and 76 of them are shown in a color photo. Many are truly wood-inhabiting fungi but a few are mycorrhizal (*Lactarius* and *Russula*) and others are incidental inhabitants of well-rotted woody debris.

The third and the major part of the book presents essential information that allows recognition of 169 species, observations on their biology and ecology, color pictures, and distribution maps. Readers should be cautious in their interpretation of the distribution maps because when I compared 8 maps with distributions in two references from the bibliography, i.e.,

numbers 142 and 145, each map was deficient. Two specific examples are (1) reference 142, titled *Albatrellus* in Michigan, includes *A. caeruleoporus, A. confluens, A. cristatus* and *A. peckianus* but Michigan is not shaded on the maps for those species, and (2) shading on the map for *Sistotrema confluens* covers southern Quebec and Nova Scotia but reference 145 notes its presence in those provinces as well as in Michigan, North Carolina, New Hampshire, New York, Vermont and Wisconsin.

Two new species, *Auricularia americana* Parm. et I. Parm. ex Audet, Boulet et Sirard and *Polyporus longiporus* Audet, Boulet et Sirard, are proposed. Several species are reported for the first time in North America, for example, *Antrodiella pallasii, Postia alni, P. folliculocystidiata, P. ptychogaster, Phellinus cinereus* and *Polyporus tubaeformis.* Although two names, *Postia minisculoides* and *P. subpendula,* are proposed as new combinations, if their basionyms, i.e., the initial name given to the fungus and its place of publication, are not in the book the new combinations are not validly published. There is a picture (plate 15 D) labeled *Punctularia strigosozonata,* that shows a typical fruit body of the orange crust fungus, *Phlebia radiata.*

The book concludes with a glossary containing approximately 250 terms with their English equivalent and a definition that often includes a reference to a page where the term is used or illustrated, an index of French and English common names, an index of scientific names, and a bibliography of 450 entries.

The book is recommended to mycologists, forest pathologists, forest ecologists, and naturalists. It is a significant contribution to our knowledge of the wood-inhabiting fungi of eastern North America.

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Manual of Vascular Plants of Northeastern United States and Adjacent Canada: Second Edition

By Henry A. Gleason and Arthur Cronquist. 2004. The New York Botanical Garden Press, 200th Street and Kazimiroff Boulevard, Bronx, New York 10458-5126 USA. 993 pages. U.S.$69.00. Cloth.

The second edition of this most useful flora was first printed in 1991. Subsequent printings have taken place in 1993, 1996, 1998, 2000 and 2002. The seventh printing which has a slightly larger page (15 cm × 23 cm, rather than 14 cm × 21.5 cm) has a slightly larger typeface. The text pages have exactly the same page numbers as the earlier printings. Some corrections were made in the 1993 volume. In 1999 nineteen individuals contributed numerous corrections but these corrections could not be included in the 2000 and 2002 printings without having an electronic version. One was finally made for the 2004 printing.

This new volume has an interesting but almost hidden drawing of a Tulip-tree, *Liriodendron tulipifera,* on the front cover. The introductory pages start with a Table of Contents which includes a list of the families in taxonomic order with their page numbers. This is followed by a Foreword by Patricia K. Holmgren and Noel H. Holmgren and short bibliographies of Henry Allan Gleason and Arthur Cronquist by Noel H. Holmgren together with photographs of them. The Glossary which preceded the synoptic keys in the earlier printings now follows the main text. This is followed by the Index to Common Names and the Index to Scientific Names which in the earlier volumes were combined.

This new volume is a most welcome step ahead with the numerous changes and corrections, and The New York Botanical Garden Press is to be congratulated even though it is still called the Second Edition.

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The Wild Orchids of North America, North of Mexico

By P. Martin. 2003. University Press of Florida, 15 Northwest 15th Street, Gainesville, Florida. USA. $27.95 paper, U.S.$45.95 cloth.

This book is a special version of a check list. The orchids included are all the recorded species found above the U.S.–Mexican border north to the Arctic and Greenland. This covers 223 species plus 24 subspecies and varieties. Additionally, this takes in 103 growth and color forms, 24 hybrids, and introduced species. The species are arranged alphabetically by scientific name, so the first entry is the charming little Spotted Orchid *Amerorchis rotundifolia.* The author gives the genus, synonyms, misapplied names, typical common name, references and range. The author also adds any appropriate comments. For each species there is a 5 × 7 cm photograph of the flower and a line drawing, generally of the whole plant. In some cases the line drawing is of the flower only which is a duplication that does not add information.

In addition to the over 60 species that can be found in Canada, and the familiar genera (*Platanthera, Cyprepedium* etc.), there are several genera that I normally associate with the tropics (*Vanilla, Laelia, Epidendrum*). While many of these are escapees from cultivation, there are a number that are native species. Not surprisingly, most of these tropical epiphytes are to be found in Florida. Indeed, I was surprised to see

how many species of *Vanilla* (of vanilla ice-cream fame from *Vanilla planifolia*) that are native to Florida.

The author uses the term "waif" to denote random individual occurrence. An example of a waif is *Laelia rubescens*, first seen in Florida in 1999. This abundant and attractive Central American species is a popular garden plant and a likely escapee. The accompanying photograph shows a white blossom. All the wild *L. rubescens* I have seen were pale lavender.

The species coverage and their current status are both accurate and up-to-date. This book contains the split between the Spotted Orchid, *Cypripedium guttatum* (Alaska and NWT), and the Yellow Spotted Orchid, *C. yatabeanum* (Kodiak Island). It includes the Newfoundland orchis (*Platanthera albida*) of Newfoundland and Greenland. The book does not contain any habitat information, nor anything of the plants' biology. Generally, nothing is given on abundance and the distributions are very generic (e.g., Manitoba east to Newfoundland south to Texas and Georgia). It would be exciting to see an expanded version of this book containing descriptive text on habitat and biology, accompanied by useable range maps. This would create an encyclopedia of North American orchids. In the meantime, this book is a very handy reference and will make a good field guide.

The book's size precludes it fitting a pocket, but it will slip easily into your back pack. As well as the usual glossary and bibliography, the author includes a well-organized key. This, combined with the clear format, makes it a no-nonsense, practical guide for botanists, naturalists and orchid enthusiasts.

ROY JOHN

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Trees of the Carolinian Forest: A Guide to Species, Their Ecology and Uses

By Gerry Waldron. Boston Mills Press, 132 Main Street, Erin, Ontario N0B 1T0 Canada. 274 pages. $24.95.

The Carolinian zone of southern Ontario is home to more than 1600 plant species. It is also the most densely populated area of the country. As a consequence, Canada's most biologically diverse forests are also among the habitats most threatened by development. Anyone with an interest in the appreciation and conservation of this natural heritage will do well to read Gerry Waldron's *Trees of the Carolinian forest*. Mr. Waldron has succeeded in producing a beautiful book that is at once a pleasure to read and quite informative. The subtitle, "A guide to species, their ecology and uses" is somewhat misleading – this is much more than a field guide. Waldron draws on a variety of historical and scientific sources to set the scene: what is the Carolinian zone? how is it related to other ecological regions? and how have successive human cultures altered this region? With the ecological context established, Waldron treats each of 73 tree species not as individuals but as members of a community.

The book starts with an ecological history of the Carolinian zone, from glaciation through settlement by indigenous and European humans up to the present. While far from an presenting an exhaustive review of post-glacial colonisation, Waldron includes enough detail to distinguish his treatment from the usual clichéd summary that appears in books of similar scope. We learn of the massive hemlock dieback 5000 years back, and that beech was averaging 20 kilometres per century as it crept north. This is a fascinating subject, and it's a shame that Waldron includes no references to his sources here. While in-text citations would be overly pedantic, including a few key references such as Pielou (1991) would be worthwhile.

Waldron uses quotations from the journals of early settlers and survey crews to illustrate both the appearance of the "virgin" forest and the attitudes of Europeans to their new homeland. Once again, he piqued my curiosity, but in this case there are perhaps no readily accessible published sources he could refer the reader to for further information.

A short discussion of the definition of the term "Carolinian" follows. Waldron covers the topic in five pages – a clearly presented summary of an important concept. This is typical of the book as a whole. The author quite capably distills complex ideas into simple language, without sacrificing accuracy in the process.

With the context established, Waldron devotes some forty pages to a discussion of biodiversity, ecological communities, and our role in their protection, and especially, their restoration. He obviously brings a lot of experience to bear on the subject. Most books on restoration focus on technical details – how, where, and when to plant a tree, etc. Refreshingly, Waldron starts by examining why (and why not) to plant trees as part of a restoration. In a region where restoration of endangered prairie habitat often begins with the removal of trees planted as part of misguided naturalization programs, this is an important discussion. That said, he acknowledges the difficulty in pursuing a "do-nothing" approach, and offers suggestions for accelerating natural successional processes. These are presented as ideas to consider, not as ready-made prescriptions for restoration success.

And so it is that on page 112 of this tree guide that the actual species treatments begin. Each species is allotted two pages. This includes the usual description of their habitat and appearance, with insights into their use in restoration and urban plantings. Unfortunately, Waldron has chosen to arrange the species alphabetically by common name. This may simplify things for the beginner, but it has the unfortunate consequence of separating walnut (*Juglans nigra*) from butternut (*Juglans cinerea*) and poplar from aspen (both *Popu-*

lus). Taxonomic arrangements are a very useful tool for learning about the relationship between species, but only if we use them!

The book is rounded out with 32 colour plates. These include a variety of habitat, habit, and close-up photographs of Carolinian trees. Some of them are quite instructive, such as the close-ups of the bark cross-sections of red and white elm, or the collection of acorns from different oak species. Others are simply beautiful images of the authors favourite organisms. One small improvement would be the inclusion of a scale for the close up shots.

Taken as a whole, this book is an incredible resource for naturalists in southern Ontario. It will serve equally well as an introduction to the ecology of the Carolinian forest for the general naturalist and as an idea book for restorationists and land managers. I look forward to the publication of a companion volume on the shrubs of the Carolinian forest, hinted at in the introduction.

Literature Cited

Pielou, E. C. 1991. After the ice age: the return of life to glaciated North America. University of Chicago, Chicago.

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ENVIRONMENT

Good News for a Change: How Everyday People are Helping the Planet

David Suzuki and Holly Dressel. 2003. Greystone Books, #201 – 2323 Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 399 pages. $24.95, U.S.$16.95

This is a paperback re-issue of Suzuki and Dressel's 2002 book originally titled *Good News for a change: hope for a troubled planet*. Either way, the book is cleverly titled to attract readers who are tired of doom and gloom environmental books. The concept is praiseworthy: bring together in one place success stories of the many and varied ways people around the world are changing the way they do things, for the benefit of their communities, their environment and their offspring. At the same time, the authors do not shy away from the bad news. Yes there are wonderful changes taking place but they are up against very serious problems and a frightening inertia embedded in our social and economic systems.

The authors have set a tremendous challenge for themselves in tackling the full sweep of environmental problems we face and in trying to represent emerging solutions from around the planet. They organize this unwieldy subject thematically with chapters on business practices, democracy, biodiversity, water, food, forests, fisheries, and air pollution. The final chapter "Breaking out of the Box" addresses the effect of our global culture on humans as natural beings and the importance of reconnecting what we do with our deepest values. Most chapters focus on one or two case studies examined in some depth with additional examples of related projects in other parts of the world. Examples are drawn from village co-operatives, family-run businesses, multi-national corporations, farms, indigenous societies and non-profit groups from such diverse places as India, Africa, Germany, Brazil, USA, Indonesia and many others. Also included are a list of organizations to contact, detailed endnotes, a brief bibliography and a reasonably detailed index. The book is a little lax in explaining the political background to some of its examples, especially Canadian ones, and a map plotting the locations for major examples would have been beneficial.

Throughout *Good News* there is an admirable effort to synthesize, and several key themes are followed. Aligning our activities with natural environmental systems results in double dividends – the costs are lower, the benefits are greater and extend beyond economics. A resource is used sustainably when it is managed by a stable community that is economically dependent on it and exerts local control and local ownership. Sustainable practices must be tailored to the specific situation; the people who follow them are humble and are constantly learning from their mistakes. Many small projects are more effective and more efficient than a single large one. We are all indigenous to this planet.

If I have any quibble with this book it is that there isn't enough of it. I want to know more about how Judy Wicks manages to make a living (and a rather substantial one) running a social activist restaurant. I want to understand how a small check dam on an intermittent stream in India can reverse desertification caused by forest removal. I want to hear from the efforts that haven't worked, because I don't believe as easy at the book makes it seem. There is no question we need more books like this, perhaps ones targeted at specific issues. Henry Mintzberg (1994) argues for the importance of identifying "emergent strategies" (new strategies that emerge spontaneously at any level of an organization) and helping them spread. That in essence is what Suzuki and Dressel have done.

Literature Cited:

Mintzberg, H. 1994. The Rise and Fall of Strategic Planning. Free Press, Simon and Schuster, New York, USA. 454 pages.

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Whose Bird?

By Bo Boelens and M. Watkins. 2004. Yale University Press, P.O. Box 209040, New Haven, Connecticutt 06520-9040 USA. x + 400 pages U.S.$35 paper.

Have you ever been curious as to who was the Bonaparte of Bonaparte's Gull fame? Was it really the feared Corsican tyrant? Now you can get a book that will answer that question and many more. The authors have researched about 1400 people who have, at one time or another, given their names to bird species. There is a cameo biography for each individual. As the book gives the accepted English names, there is a very slight bias to the coverage. European and American naturalists dominate the list, but to be fair Professor Ijima (Ijima's Warbler, *Phylloscopus ijimae*) gets his credit. Montezuma does not fare as well. He gets a single sentence biography stating he was Emperor of the Aztecs. Actually, Montezuma I, Emperor of Mexico, was a remarkable man. He was a victorious general before he succeeded his uncle as emperor in 1436. He is only recognized for his Quail, with no mention of his strikingly handsome Oropendola. In contrast, Californian Alberto Treganza (Treganza's – now Great Blue – Heron) gets almost a whole page.

Many of the names have fallen by the wayside. The Bancroft's Night Heron is now called by the more descriptive name of Yellow-crowned Night Heron. The loss of some names is a benefit. I would have trouble spelling and pronouncing Sjöstedt (Sjöstedt's Owlet, now Barred Owlet). No disrespect to Mr. Helmut Sick (Sick's Manakin), but I think the Golden-crowned Manikin would prefer its new name. However, I am sad to see Lear's Macaw is now an Indigo Macaw. Edward Lear, mostly known for his nonsense poems, was a remarkable Victorian bird artist who deserves a memorial. William MacGillivray's name lives on as MacGillivray's Warbler (*Oporornis tolmia*) but his son's bird, MacGillivray's Petrel, is now the Fiji Petrel, but scientifically is *Pseudobulwaria macgillivrayi* (The generic name honours the Reverend James Bulwer.).

Some of these names are still current. Thekla Lark, named after the dying daughter of a German naturalist is still a Thekla Lark. Of the 17 species named for the pioneering Dutch ornithologist Coenraad Temmink, six still remain. I am delighted that the Adélie Penguin's name remains intact as it really suits this charming bird. Be thankful that Admiral Jules-Sebastien-César Dumont D'Urville named it for his wife and not himself.

There are some odd stories in the book. I was particularly titivated by the tale of Colonel George Montagu (Montagu's Harrier) who was cashiered from the British army for "provocative marital skirmishing" and thereby took up the study of science. I will never look at the harrier the same way again!

There are some names that are conspicuously absent. Roger Tory Peterson, Peter Scott (Scott's Oriole is named for Winfield Scott) and James Fisher were probably born too late in history. Linneus or Linné, who invented the nomenclature system, was alive in the right era, but remains un-honoured.

As well as the cameos, the authors have collected together those people who shared a characteristic in common, such as diplomats, Germans or those who died of gunshot. Many of the entries have a black-and-white portrait of the person featured. For those of you who love trivia or are keen naturalists preferably both, this is a fun book.

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Forest Dynamics and Disturbance Regimes: Studies from Temperate Evergreen-Deciduous Forests

By Lee E. Frelich. 2002. Cambridge University Press, 40 West 20th Street, New York, New York 10011-4221 USA. 266 pages. GBP50 (U.S.$80).

Disturbance is ubiquitous in forest ecosystems. Forested landscapes are best viewed as an integration of climatic, biotic, edaphic and geomorphic processes that determine the character of disturbance events occurring over a wide range of temporal and spatial scales. Disturbed by the extremes of either catastrophic, stand-replacing events that may include fire, insect outbreak, and extensive windthrow, or periodic, small-scale gap processes mediated by fungal pathogens, forests are in constant flux when viewed from a landscape perspective. Such a wide range in the periodicity, intensity and scale of disturbance events, and the diversity of bio-edaphic interactions create a complex, fluid, heterogeneous landscape.

Lee Frelich, founder and director of the University of Minnesota Center for Hardwood Ecology, introduces the reader to the significant disturbances that have shaped, and continue to shape, the hemlock-hardwood forests of the northern regions of the Lake States (Minnesota, Wisconsin, and Michigan). For the past two decades Dr. Frelich has dedicated himself to understanding the stand- and forest-level dynamics of these deciduous-to-boreal transition forests. He forms part of a long tradition of university and government (United States Forest Service) forest ecology research, much of which is scattered in scientific journals and government reports. *Forest Dynamics and Disturbance Regimes* provides for the first time, in an engaging, well-illustrated, and synthetic format, the fruit of this rich research legacy.

"Under what conditions do forests change or stay the same?" Thus might one summarize the intent of this book. Introductory chapters set the scene by describing the Great Lakes temperate forests and their disturbance regimes dominated by fire, wind, insect outbreaks and mammalian herbivory. Of significance to the practicing forest ecologist will be the chapter on sampling and interpretative techniques used to detect and interpret forest disturbance regimes. Emphasis is placed on the use of tree radial increment patterns as a valuable source of insight into stand disturbance history.

Frelich emphasizes the critical role played by disturbance in both stand development and forest succession. He properly distinguishes between stand development and succession, both of which are often confused in the literature. Disturbance will always initiate a new cycle of stand development in the regenerating, post-disturbance forest. However, disturbance may or may not initiate a species change or a new successional sequence.

Consideration is also given to the differing effects of disturbance at both the stand- and landscape-level. This distinction is important, especially given the wide temporal and spatial scales at which disturbances may occur. Furthermore, instability at the stand level may be interpreted as stability at the landscape level. Interpretation often depends on the scale of investigation.

A particular strength of this work is Frelich's ability to engage the complex interaction of different disturbances. Frelich not only introduces the wide diversity of temporal and spatial patterns of forest change, but even more importantly, highlights often counter-intuitive insights into forest change and continuity. I found the following particularly noteworthy: (1) the nonlinear response of forest species composition to disturbance severity, (2) the cause and development of patchy hardwood-softwood mosaics, (3) clarifying taxonomy of the concept of old-growth, (4) how different forest types can exist on relatively homogeneous sites, and (5) the multiple successional pathways open to any particular forest type. Frelich's final chapter summarizes the notion of forest stability. It provides conceptual models of forest response to disturbance, 3-D models of succession in different forest types, and a final classification of four different types of forest landscape.

This work is particularly important as humans continue to "disturb" forests, especially by commercial forestry. Before any claims can be made about the desirability of the changes created by human interventions, it is essential to properly comprehend the range of natural forest disturbance regimes and the associated changes in forest structure and tree species composition.

The book addressees the scientific community and would properly of greatest interest to forest ecologists and all students of forest change. The judicious mix of empirical case studies, hypothetical examples and conceptual models helps the reader to think "beyond the box." The many line drawings, flow charts and black-and-white photographs help to clarify the different concepts.

As one is reminded in the subtitle, this book focuses exclusively on the temperate evergreen-deciduous forests (of the Lake States). While it is certain that many of the concepts developed from research in this forest type are applicable to other forest types, it is wise to resist any quick and easy transfer of ideas. Forests grow in conditions that span a wide ecological spectrum, a situation that often resists our human tendency to categorize and classify. Be that as it may, this book provides rich and substantive insight into this well-studied – and much-loved – forest region at the deciduous-boreal interface.

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Snowshoes & Spotted Dick; Letters from a Wilderness Dweller

By Chris Czajkowski. 2003. Harbour Publishing Co. Ltd., PO Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 298 pages. Paper U.S.$24.95

This book is a one-sided account of the wilderness experiences of a woman of extraordinary independence, as she writes letters to a friend named Nick. Chris Czajkowski is an author and wilderness guide who has chosen a life of relative and geographic isolation on remote property where she lives three quarters of the year in the coast mountains of British Columbia, 480 kilometres north of Vancouver. There is no telephone or mail delivery and the radio only works on clear days. The computer used while writing the book draws the electricity required to function from solar panels. The visitors to the eco-tourism business "Nuk Tessli Alpine Experience" are brought in by float plane, along with any supplies and news from the outside world.

This, the fourth book by the same author, is her account of the incredible effort to build a third cabin on the property. Its format of letters scribed to a friend in Germany is generously interspersed with some textual description, a few black-and-white pictures and hand-drawn sketches.

The reader is drawn in by expressive language evoking in the imagination pictures of the breathtaking vistas, and natural surroundings so that you feel almost as though you have been there, perhaps as a visitor to "Nuk Tessli". The added mystery of "what is Spotted Dick?" is a cute grab but is just a little overdone.

The easy flow of the language makes the 298 pages an easy read, despite the occasional construction jargon.

The actual process of building a log cabin in the woods, particularly in such a remote location, is fascinating. The cabin is built in several steps, over numerous months, using hand tools, chainsaws, and, occasionally, some friends.

There are a few drawbacks from the enjoyment of this book though, especially without having read the first three. The first is that in this book there are a number of interesting stories that are alluded to but not told in detail because they've been recorded in the previous books. The second is that the letters are all to Nick and because it does not include the letters written from him, it feels a bit like being in the same room with someone on the phone – you hear half the conversation and although you get the gist of the whole, you feel the missing of the other half. The third and most perplexing is the lack of description of the characters or their relationship with each other. The reason this is perplexing is because the author herself describes this criticism received from a book reviewer – and then simply passes it off with "The trouble is, I live with the people I write about. Experience has shown that no matter how innocuous a portrait I paint, the subject will find something about which he or she is unhappy." While I am sure this could be true, the book would earn a wider audience if it were not written for those people alone.

DAWN BURNETT

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Natural Grace: The Charm, Wonder, & Lessons of Pacific Northwest Animals & Plants

By William Dietrich. 2003. University of Washington Press, 1326 Fifth Avenue, Suite 555, Seattle, Washington 98101-2604 USA. 236 pages. U.S.$19.95

Natural Grace is a contemporary example of the medieval book of beasts called a bestiary. Bestiaries were very popular during the Medieval Period, and focused on the life of nature as a model or paradigm for human behavior. These books were not scientific in the contemporary sense of the term, but instead combined religious and moral teaching with a close observation of nature, zoological commentaries, and fabulous and fictitious creatures. Rather than being studied in and of itself, nature was considered symbolic of both the virtue and moral life of human beings. While Deitrich's work certainly provides the reader with a more sophisticated scientific understanding of nature, the subtitle of the book betrays its "bestiary" lineage as the reader is invited to appreciate the charm, wonder, and lessons of a variety of creatures and natural phenomena.

This collection of essays is adapted from William Dietrich's popular articles in the *Seattle Times' Northwest Magazine*. The author divides his work among four themes: (1) the common and ubiquitous creatures that we often take for granted, (2) the itty-bitty world that ranges from soil to spiders, (3) the rhythmic, clockwork world of tectonics and tides, and finally, (4) the iconic symbols of the Pacific Northwest including, among others, the bald eagle and the killer whale or orca.

Dietrich is gifted with the contemplative eye. Follow his gaze and you will enter a world of delight and amazement. We live side by side with other creatures and are immersed within the workings of nature. But often, we are oblivious to the ways of our environs, so intent and fascinated are we with our own creations and fabrications. Dietrich pries apart our fabricated world and invites us to direct our gaze out beyond the confines of culture. He calls us to a long loving gaze on the other of nature.

This contemplative gaze is a virtue that strengthens with time and practice. Dietrich is a patient and humorous guide, gently leading the reader to grow in knowledge of the natural world; knowledge, not simply of the biological or physical facts, but of the beauty, significance, and yes, even mystery inherent in the subject of our gaze. Of special interest is the manner by which the author weaves together culture and nature. Whether it be the forces of nature that define the boundaries of human culture and provide the myriad free ecological services that allow us our cities and farms, or the manner in which particular species have become embedded in our folk and cultural lore, the reader is left with the knowledge that we are dependent on the "others" of nature far beyond our physical survival.

Human ignorance instills fear, and fear breeds violence and destruction. *Natural Grace* sets a contrary path. Knowledge of the other, of nature, can lead to intimacy, and intimacy can be the foundation of love. Love, in turn, leads to mutuality, care, and concern for the other. Dietrich's melodious writing can indeed lead one to greater love of nature and hopefully, action on behalf of nature.

This book is a lovely blend of nature and culture, of scientific vulgarization and social lore. You will learn much about the natural history of the Pacific Northwest. As well, I think, you will learn about how we (and maybe you yourself) relate to the natural world, and how that relationship has changed with time, and how it may or must change in the future.

Given Dietrich's place of habitation (Seattle), this book focuses on the State of Washington, with excursions south to Oregon and north to British Columbia. So, if you call the Pacific Northwest your home, you will learn much about your "neighbours." However, regardless of one's geography, Dietrich's work is more a work of perspective, rather than of content. His actors live and work in the Pacific Northwest, but the perspective shared is universal. No matter where you

live, the long, loving, contemplative gaze on the real is always a possibility.

The 12th century Cistercian monk, Saint Bernard of Clairvaux, once said; "I have discovered that you will find far more in the forests than in books; trees and stones will teach you that which you cannot learn from any master." Turn a discerning eye to the creatures and processes that surround you and you will enter a world of marvel and beauty. Let *Natural Grace* be your companion and guide.

JOHN MCCARTHY, S.J.

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Tales from the Underground: A Natural History of Subterranean Life

By David W. Wolfe. 2001. Perseus Publishing, 5500 Central Avenue, Boulder, Colorado 80301 USA. 221 pages. $27.50

Tales from the Underground is a MUST read for any naturalist interested in what's happening under our feet. The book is engaging, well-written, and filled with information that is truly awesome.

In the introduction, author David Wolfe, Associate Professor of Plant Ecology at Cornell University, invites his "subterranean-impaired" readers to use their imaginations and join him on a dive trip into a mysterious world scientists are only just beginning to understand. Wolfe launches the journey with a description of the various soil "profiles", also known as layers or horizons, and the organisms that inhabit them. Some of the life forms I had never heard of; others I had never thought about in the way Wolfe describes them.

Take plants, for example. Wolfe starts by praising their display of foliage aboveground. He then points out that plants are unique because they simultaneously inhabit both the surface and sub-surface realms. He calls them the "great mediators between the two realms", and explains their functions both above and below the ground, with a focus on their buried other half: roots.

In Part I of the book, "Ancient Life", Wolfe covers a lot of ground. He discusses theories of the origin of life, the basic elements necessary for the evolution of life, Earth's advantage as a life-generating planet, and speculation pointing to the subterranean realm as the place where life began. He also introduces "extremophiles", creatures that live in severe conditions thousands of feet underground, where pressure and temperatures are extraordinarily high, and where there is neither light nor oxygen – the postulated setting for the beginning of life.

Wolfe also describes Carl Woese's discovery of the amazing genetic diversity of these extremophiles, and discusses how that discovery changed the universal tree of life. Originally composed of bacteria, plants, fungi, animals and protozoa, the tree of life now has only three branches – bacteria, archaea (the extremophiles) and eukarya (with plants and animals as two small twigs). It's a fascinating and humbling picture.

In Part II, "Life Support for Planet Earth", Wolfe dedicates an entire chapter to Charles Darwin and the lasting influence of the renowned scientist's meticulous and painstaking work. Wolfe also portrays certain inconspicuous subterranean creatures and the important roles they play in cycling essential elements and facilitating the flow of energy – processes that sustain life on this planet. He also discusses the dual roles played by soil with respect to plant and animal diseases; some soil microbes cause diseases, while others provide powerful antidotes.

The third part of the book, "The Human Factor", describes the enormous footprint of *Homo sapiens* on the planet. Wolfe tells the sobering, appalling story of human activities and their devastating impacts on wildlife such as prairie dogs, black-footed ferrets, and burrowing owls, and on soil integrity in general. Descriptions of soil erosion and the 1930s dust bowl crisis are particularly gripping.

Yet despite the doom and gloom, Wolfe ends on an optimistic note. The very last sentence of the book reads, "It is my hope that as more of us become aware of the life beneath our feet, and its relevance to our well-being, we will be inclined to work together to maintain the biological integrity of the underground, and preserve some of what we find there for future generations" – words we have heard before in one form or another, but good to see repeated in this context.

Tales from the Underground is David Wolfe's first book, and I hope it isn't his last. He has a pleasant and easy-to-read writing style, and manages to convey scientific concepts so that even a non-scientific type like me can understand. *Tales from the Underground* has found a permanent place on my bookshelves.

R. SANDER-REGIER

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NEW TITLES

†Available for review * Assigned for review

Zoology

* **Amphibian Decline: An integrated analysis of multi stressor effects.** By Greg Linder. 2004. SETAC North America, 1010 North 12th Avenue, Pensacola, Florida. U.S.$98 Cloth.

Annotated Checklist of Birds of Chile. By M. Marin. 2004. Lynx Edicions, Barcelona, Spain. 144 pages. U.S.$15.75 [in English and Spanish].

Biology of Sharks and their Relatives. By J. Carrier, J. Musick and M. Heithus. 2004. CRC Press, 2000 NW Corporate Boulevard, Boca Raton, Florida. U.S.$99.95.

* **Birds of Belize.** By H. L. Jones. 2004. University of Texas Press, Austin, Texas. 317 pages, U.S.$60.00 Cloth, $34.95 Paper.

Birds of South Asia. By P. Rasmussen and J. Anderton. 2004. Lynx Edicions, Barcelona, Spain. U.S.$95 Cloth.

Birds of Spain. 2004. Lynx Edicions, Barcelona, Spain. 296 pages. U.S.$49 [in English and Spanish].

Birds of the Raincoast. By H. Thommasen and K. Hutchings. 2004. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia. 260 pages. U.S.$24.95.

The Exotic Amphibians and Reptiles of Florida. By W. Meshaka, B. Buttergield and J. Hauge. 2004. Krieger Publishing P.O. Box 9542 Melbourne, Florida 32902-9452. 166 pages. U.S.$34.50.

* **Hawks and Owls of the Great Lakes Region & Eastern North America.** By C. Earley. 2004. Firefly Books Ltd., 3680 Victoria Park Avenue, Toronto, Ontario, M2H 3K1. 128 pages. $16.95 Paper, $24.95 Cloth.

† **Orca – Visions of the Killer Whale.** By Knudtson. 2004. Greystone Books, Vancouver, British Columbia. xvii +110 pages, $19.95.

Pacific Reef and Shore. By R. Harbo. 2004. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia. 80 pages. U.S.$9.95.

Reproductive Biology and Early Life History of Fishes in the Ohio River Drainage. By T. Simon and R. Wallus. 2004. CRC Press, 2000 NW Corporate Boulevard, Boca Raton, Florida U.S.$119.95.

* **Self-Portrait with Turtles: A Memoir.** Edited by David M. Carroll. 2004. Houghton Mufflin Co., 222 Berkeley Street, Boston, Massachusetts 02116. 192 pages. 40 black-and-white line drawings and halftones. $23.00 Hardcover.

Botany

* **Arboretum America: a Philosophy of the Forest.** By Diana Beresford-Kroeger. 2003. University of Michigan Press, 839 Greene Street, P.O. Box 1104, Ann Arbour, Michigan. 196 pages. U.S.$52.50.

Botanical Latin: Fourth Edition. By William T. Stearn. 1992 [Re-issued as a paperback 2004] Timber Press, 133 SW 2nd Avenue, Suite 450, Portland, Oregon, USA. 560 pages. Paperback, U.S.$29.95.

* **Manual of Vascular Plants of Northeastern United States and Adjacent Canada.** By H. Gleason. 2004. New York Botanical Gardens, 200th Street and Kazimiroff Boulevard, Bronx, New York. 993 pages. U.S.$69.00.

The Orchid in Lore and Legend. By Luigi Berliocchi. 2000 [Re-issued as a paperback 2004] Edited by Mark Griffiths. 2000 Timber Press, 133 SW 2nd Avenue, Suite 450, Portland, Oregon, USA. 200 pages. Paperback, U.S.$19.95.

The Secrets of Wildflowers. By J. Saunders. 2004. The Lyons Press, 246 Goose Lane, P.O. Box 480, Guilford, Connecticut. 304 pages. U.S.$24.95.

Wildflowers of the Seacoast in the Pacific Northwest. By J. Trelawny. 2004. Harbour Publishing, P. O. Box 219, Madeira Park, British Columbia. 80 pages. U.S.$12.95.

Environment

Arctic National Wildlife Refuge. By S. Banerjee. 2004. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia. 176 pages. U.S.$36.95.

† **The Bird Almanac.** By D. Bird. 2004. Key Porter Books, 70 The Esplanade, Toronto, Ontario, Canada. xvii + 460 pages, not illustrated. $24.95.

* **Dancing at the Dead Sea – Tracking the World's Environmental Hotspots.** By Alanna Mitchell. 2004. Key Porter Books, 70 The Esplanade, Toronto, Ontario M5E 1R2 Canada. 259 pages. $26.95.

Estuarine Research, Monitoring and Resource Protection. By M. Kennish. 2004. CRC Press, 2000 NW Corporate Boulevard, Boca Raton, Florida. U.S.$119.95.

Important Transboundary Belarussian-Lithuanian and Lithuanian-Russian Wetlands. By L. Raudonikis, A. Skuratovich, L. Balčiauskas, E. Drobelis, D. Grishanov. 2003. Botanikos institutas, Vilnius, Lithuania.

* **The History of Ornithology in Virginia.** By D. Johnston. 2004. University of Virginia Press, P.O. Box 400318, Charlottesville, Virginia. x + 219 pages. U.S.$35.

The Lewis and Clark Columbia River Water Trail: A Guide for Paddlers, Hikers, and Other Explorers. By Keith G. Hay. 2004. Timber Press, 133 SW 2nd Avenue, Suite 450, Portland, Oregon, USA. 264 pages. Paperback, U.S.$19.95.

* **Politics of the Wild – Canada & Endangered Species.** Edited by K. Beazley and R. Boardman. 2004. Oxford University Press, 70 Wynford Drive, Don Mills, Ontario, Canada. x + 254 pages, not illustrated. $29.95.

* **A Primer of Ecological Genetics.** By J. Conner and D. Hartt. 2004. Sinauer Associates, Box 407, Sunderland, Massachusetts, USA. 207 pages. U.S.$34.95.

† **Resource and Environmental Management in Canada.** Edited by B. Mitchell. 2004. Oxford University Press, 70 Wynford Drive, Don Mills, Ontario. x + 600 pages, $29.95.

* **Whose Bird?** By B. Boleus and M. Watkins. 2004. Yale University Press. 384 pages. U.S.$35.00 paper.

Children's books

Saving Birds: Heroes around the world. By P. Salmansohn and S. Kress. 2004. Tilbury House, Gardiner, Maine. 40 pages. U.S.$16.95.

King Of Fish: The Thousand Year Run of Salmon. By E. Bauer. 2003. Voyageur, Stillwater, Minnesota. 160 pages. U.S.$29.95.

News and Comment

Point Pelee Natural History News 3(4)

The Winter 2003 issue, volume 3, number 4, pages 53-68, contains: Point Pelee: Its Evolution and Structure (Alan S. Trenhaile) — Noteworthy Bird Records: September to November 2003 (Alan Wormington) — More Cave Swallows: The Fall of 2003 (Alan Wormington) — Point Pelee Christmas Bird Count: December 15, 2003 (Sarah E. Rupert) — Fox Squirrels at Point Pelee: 1977, 1990 and 1997 (Alan Wormington) — In the Field (Ross's Gull: Second Record for Point Pelee; "Harlan's" Red-tailed Hawk: New to Point Pelee).

The *Point Pelee Natural History News* was edited by Alan Wormington (e-mail: wormington@juno.com). Editorial Assistants were Gordon D. Harvey and Michelle T. Nicholson; web site www.wincom.net/~fopp/Natural_History_News.htm. This is the last issue as the Board of Directors of the publisher, The Friends of Point Pelee, has decided to terminate the publication due mainly to the lack of material being submitted. All past issues are available in the Nature Nook Book Store in Point Pelee National Park's Visitor Centre or by mail from the Friends of Point Pelee, 1118 Point Pelee Drive, Leamington, Ontario N8H 3V4 Canada; phone 519-326-6173; e-mail: fopp@wincom.net.

COSEWIC Assessment Results November 2003

This update on Canadian Species at Risk issued by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is 44 pages and contains: About COSEWIC, (mandate, membership, definitions) — Summary Tables [COSEWIC species designated in five "risk" categories and in Not at Risk, and Data Deficient categories (Tables 1-3)] — Results of November 2003 COSEWIC meeting (Tables 4-5) — COSEWIC Assessment Results — Explanation of symbols — Species examined in five "risk" categories (Table 6), Not at Risk (Table 7), and Data Deficient (Table 8) — Record of Status Re-examinations — Record of Name Changes. Listed are 12 extinct, 21 extirpated, 160 endangered, 108 threatened, and 140 of special concern. Of the 441 forms in these categories, 65 are mammals, 58 birds, 31 reptiles, 19 amphibians, 78 fishes, 16 arthropods, 19 molluscs, 140 vascular plants, 9 mosses, and 6 lichens. In addition, 32 forms have been considered and found not at risk, and 29 to be data deficient.

This publication is available from COSEWIC Secretariat, Canadian Wildlife Service, Environment Canada, Ottawa, Ontario K1A 0H3. See Web site: http://www.cosewic.gc.ca.

Froglog: Newsletter of the Declining Amphibian Populations Task Force (61)

Number 60, February 2004. Contents: A Workshop on the Amphibians of Madagascar at Giand (Franco Andreone) — Amphibian Colonization of Mitigation Wetlands in Nebraska (Mark M. Peyton) — Annual Meeting Report from Canada (David Galbraith) — A Study of the Plethodontid Salamander Populations at Raccoon Creek State Park, Pennsylvania (Jennifer D. Haney and Mary S. Kostalos) — Reports on DAPTF Seed Grants — Froglog Shorts — New Book on Amphibian Declines (*Amphibian Declines: An Integrated Analysis of Multiple Stressor Effects*. 2003. SETAC Press, Pensacola, Florida: http://www.setac.org/pubs.html).

Froglog is the bi-monthly newsletter of the Declining Amphibian Populations Task Force of The World Conservation Union (IUCN)/Species Survival Commission (SSC) and is supported by The Open University, The World Congress of Herpetology, and Arizona State University. The newsletter is edited by John W. Wilkinson, Department of Biological Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, United Kingdom; e-mail: daptf@open.ac.uk. Funding for *Froglog* is underwritten by the Detroit Zoological Institute, P. O. Box 39, Royal Oak, Michigan 48068-0039, USA. Publication of issue 61 was also supported by Peace Frogs www.peacefrogs.com and by RANA and the US National Science Foundation grant DEB-0130273.

The Boreal Dip Net/L'Epuisette Boreal: Newsletter of the Canadian Amphibian and Reptile Conservation Network – Reseau Canadien de Conservation des Amphibiens et des Reptiles

8(1) January 2004

Contents: Editor's Note: thanks to sponsors TD Bank Financial Group, TD Friends of the Environment, The Pelee Island Winery, Parks Canada [Kerrie Serben] — A note about our acronym [David Galbraith] — CARCNET/RECCAR 2003: The Pelee Isand Experience [David Galbraith] — Summary of Species at Risk Proceedings from the 8th Annual Meeting of CARCNET/RECCAR and the 3rd Annual Pelee Island Winery Endangered Species Festival (ESF) [Kim Barrett and Ben Porchuk] — The Lake Erie Watersnake: A 23-year Perspective on Microevolution, Population Status, and Recovery Planning [Richard B. King] — Loving Nature to Death [Ron Brooks] — Another Leap into Learning [Sara L. Ashpole] — Books to Get: Turtles [Anita Baskin-Salzberg and Allen Salzberg]; A guide to creating vernal ponds — Endangered Northern Leopard Frog Reintroduced into East Kootenay After 20 Year Disappearance — Frogs and Toads of Canada CD — Current CARCNET/RECCAR Board of Directors — New Species of Salamander Found in Revelstoke [Larry Halverson] — Paper on Traffic Mortality and Turtles [reviewed by David Seburn] — Coming soon... CARCNET 2004 September 24-27 Edmonton — Membership in CARCNET/ RECCAR.

For information on membership in the Canadian Amphibian and Reptile Conservation Society/Reseau Canadien de Conservation des Amphibiens et des Reptiles ($10 students, $16 non-students] contact Bruce Pauli, Canadian Wildlife Service, National Wildlife Research Centre, Carleton University, Raven Road, Ottawa, Ontario K1A 0H3. Web site: http://www.carcnet.ca/

Annotated List of the Arctic Marine Fishes of Canada

In 2004 Fisheries and Oceans Canada, Central and Arctic Region, Winnipeg, Manitoba, printed a limited number of copies of the *Annotated List of the Arctic Marine Fishes of Canada* by B. W. Coad and J. D. Reist as Canadian Manuscript Report of Fisheries and Aquatic Sciences 2674, iv + 112 pages. A primary list covers the 189 species representing 115 genera in 48 families of marine and anadromous fishes in Canadian Arctic and marine waters. Given under scientific name, authority, and description date, are the Common Name, Provinces/Territories of occurrence, Ecozone, Distribution (ocean and extralimital), Numbers, Size (maximum), and Biology (depth, food, commercial importance). An extralimitial list gives 83 species occurring in adjacent areas that might eventually be recorded in Canadian Arctic waters annotated as eastern (eastern Davis Strait, southwest Greenland) and western (western Beaufort Sea of Alaska from Point Barrow eastwards). A brackish water list gives 36 species whose life is usually spent entirely in fresh waters but which may enter estuaries and seashore pools in the Canadian Arctic. There are 3 tables (species by province and territory, by ecozones, and by distribution (Alaska, Atlantic, Eurasia)); 2 maps (Canadian Arctic waters and ecozones with this area); and two appendicies: one giving an alphabetical listing of scientific names of families with common names in English, French, Inuktitut and Inuvialuktun and one giving an alphabetical listing of species by scientific name with notation of new to Arctic, new to Canada, and page number in text.

Copies of this report are available from Fisheries and Oceans Canada Central and Arctic Region, Winnipeg, Manitoba R3T 2N6 Canada: e-mail reistj@dfo-mpo.gc.ca [Catalogue number Fs 97-4/26/2674E, ISSN 0706-6473].

Marine Turtle Newsletter (103)

January 2004. 32 pages: ARTICLES: Behavior of Green Sea Turtles in the Presence and Absence of Recreational Snorkellers — Turtle Strandings in the Southern Eritrean Red Sea — First Confirmed Occurrence of Loggerhead Turtles in Peru — A Harness for Attachment of Satellite Transmitters on Flatback Turtles — NOTES: Nesting of the Hawksbill Turtle in Shidvar Island, Hormozgan Provance, Iran — MEETING REPORTS — OBITUARIES (Henry H. Hildebrand 1922-2003; C. Robert Shoop 1935-2003) — ANNOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

The Marine Turtle Newsletter is edited by Brendan J. Godley and Annette C. Broderick, Marine Turtle Research Group, School of Biological Sciences, University of Exeter, Exeter EX4 4PS United Kingdom; e-mail MTN@seaturtle.org; Fax +44 1392 263700. Subscriptions and donations towards the production of both the MTN and its Spanish edition NTM [Noticiero de Tortugas Marinas] should be made online at <http://www.seaturtle.org/mnt/> or c/o SEATURTLE.ORG, 11400 Classical Lane, Silver Spring, Maryland 20901 USA.

Ontario Natural Heritage Information Centre Science and Information Newsletter 9(1) Winter 2004

Contents of this 20 page issue: FEATURE ARTICLES: Decade of Achievement (NHIC 10th anniversary celebrated 9 December 2003) — A Decade of Ontario Botanical Dsicoveries; 2003 PROGRAM HIGLIGHTS: NHIC Staff Participate in James Bay Coastal Vegetation Study — Notes on the Vegetation and Flora of Flooding River Shores — A Profile of Natural Areas Recently Added to the Natural Areas Database; 2003 PROJECT HIGHLIGHTS: NHIC Conducts Turtle Surveys — NHIC Coordinates Odonata and Reptile Surveys — Update on the Great Lakes Conservation Blueprint Projects — Identifying Key Natural Areas and Linkages in Southern Ontario — NHIC's Southern Region Element Occurrence Prioritization Project; NEWS AND NOTES: Species at Risk: A Diversity of Designations — What's in a Name? Changes to the Provincial Amphibian and Reptile Lists — NHIC Attends Pelee Island Events — NatureServe Canada and Parks Agency sign MOU — NatureServe Participates with CWS on Species at Risk Information Needs Analysis — Additions to the COSEWIC list — Minister visits NHIC; BOOK REVIEWS; NHIC STAFF INFORMATION.

Mailing address for Natural Heritage Information Centre, Ontario Ministry of Natural Resources, 300 Water Street, 2nd Floor, North Tower, P.O. Box 7000, Peterborough, Ontario K9J 8M5, Canada; www.mnr.gov.on.ca/MNR/nhic.cfm. Web page: http://www.mnr.gov.on.ca/MNR/nhic.html

Erratum Canadian Field-Naturalist 117(1)

Ballard, Warren B., Matthew A. Cronin, Martin D. Robards, and **William A. Stubblefield.** 2003. Heavy metal concentrations in Arctic Foxes, *Alopex lagopus,* in the Prudhoe Oil Field, Alaska. Canadian Field-Naturalist 117(2): 119-121.

The abbreviation for concentrations in micrograms per gram of dry weight should be corrected in two places. On page 120 "mg/g" left column line 18, and right column line 21, should be "μg/g".

Erratum Canadian Field-Naturalist 117(2)

Lindquist, E. S., C. F. Aquadro, D. McClearn, and **K J. McGowan.** 2003. Field identification of the mice *Peromyscus leucopus noveboracensis* and *P. maniculatus gracilis* in central New York. Canadian Field-Naturalist 117(2): 184-189.

On page 4, Figure 1, 1A was repeated for 1B. The correct 1B is shown below with 1A.

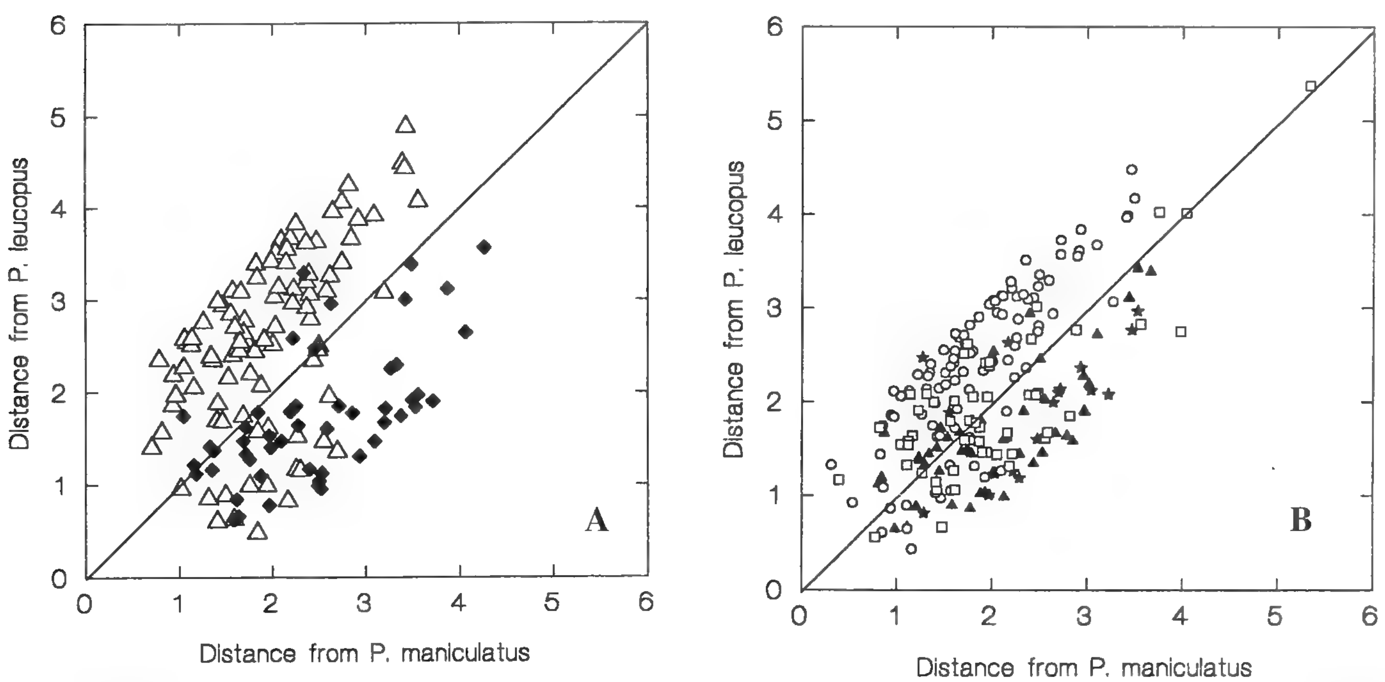

FIGURE 1. Classification of *P. l. noveboracensis* and *P. m. gracilis* using the discriminant-function coefficients given in Table 2. Figure 1a shows the classification of adults only. Figure 1b shows the classification of adults and juveniles. Open and closed symbols denote *P. m. gracilis* and *P. l. noveboracensis*, respectively. In Figure 1b, *P. m. gracilis* is indicated by open circles and squares (adult and juvenile, respectively), and *P. l. noveboracensis* by closed triangles and stars (adult and juvenile, respectively).

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Please submit, **to the Editor,** in either English or French, **three** complete manuscripts **written in the journal style.** The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Print the manuscript on standard-size paper, **doublespace throughout,** leave generous margins to allow for copy marking, and **number each page.** For Articles and Notes provide a bibliographic strip, an abstract and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names should be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in the text or in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Check recent issues (particularly Literature Cited) for journal format. Either "British" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations

Photographs should have a glossy finish and show sharp contrasts. Electronic versions should be high resolution. Photographic reproduction of line drawings, **no larger than a standard page,** are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the journal.

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Authors **must share in the cost of publication** by paying \$80 for each page, plus \$15 for each illustration (any size up to a full page), and up to \$80 per page for tables (depending on size). Authors may also be charged for their changes in proofs. Reproduction of color photos is extremely expensive; price quotations may be obtained from the Business Manager. Reprint order forms are included when galley proofs are sent to authors. If grant or institutional funds are not available, club members and subscribers may apply for a waiver of charges for the first five pages.

Limited journal funds are available to help offset publication charges to authors with minimal financial resources. Requests for financial assistance should be made to the Business Manager when the manuscript is accepted.

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An order form for the purchase of repents will accompany the galley proofs sent to the authors.

Francis R. Cook, Editor
13078 Land O'Nod Road
RR 3 North Augusta, Ontario KOG IR0 Canada

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125 Years' Anniversary:

(continued on inside back cover)

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The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

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Her Excellency The Right Honourable Adrienne Clarkson, C.C., C.M.M., C.D.
Governor General of Canada
His Excellency John Ralston Saul, C.C.

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

To communicate with the Club, address postal correspondence to: The Ottawa Field-Naturalists' Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2, or e-mail: ofnc@achilles.net.
For information on Club activities telephone (613) 722-3050 or check http//www.achilles.net/ofnc/index.htm

The Canadian Field-Naturalist

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COVER: Brown Bear, *Ursus arcts,* watches Gray Wolf, *Canis lupus,* in the Katmai National Park and Preserve in southwest Alaska. See paper by Smith, Partridge, and Shoen pages 247-250 (Kent Fredrikson photograph).

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Morphology and Population Characteristics of Vancouver Island Cougars, *Puma concolor vancouverensis*

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Cougars are a management concern on Vancouver Island because they are a top predator and because there have been frequent attacks on humans on the island. However, little is known about Cougar ecology in the Pacific Northwest of North America. We studied Cougar morphology and population characteristics as part of a larger study in two areas on Vancouver Island. We derived a multivariate measure of body size to describe changes with age and sex. Body size was similar in the two study areas. Survival rates for adult females were higher than those reported elsewhere; however, hunters avoided shooting females in general, and radio-collared Cougars in particular. Litter size at first detection was lower than reported in many other studies and may be related to food availability.

Key Words: Cougars, *Puma concolor vancouverensis,* morphology, survival, mortality, natality, Vancouver Island, British Columbia.

The Mountain Lion, or Cougar (*Puma concolor vancouverensis*), is one of the two main large predatory carnivores in the forests of Vancouver Island, British Columbia, Canada. It also has a long history of interactions with humans as a nuisance (livestock predation) and as a game species (Beier 1991). The incidence of Cougar attacks on humans in North America is also highest on the island. However, little is known about the ecology of Cougar in this part of its range, mainly because this subspecies inhabits dense forests typical of coastal British Columbia. We examined Cougar morphology and population characteristics in two study areas on Vancouver Island to investigate the effects of age, sex, and location on body size, and to determine survival rates and reproductive characteristics.

Methods

Research was conducted on a 700-km^2 area near Northwest Bay (NWB), British Columbia, and on a 1000-km^2 area centred on the Adam and Eve River valleys (AE) approximately 300 km northwest of NWB (Figure 1). Principal habitats at NWB consisted of different seral stages of Douglas Fir (*Pseudotsuga menziesii*), Western Hemlock (*Tsuga heterophylla*), and Western Redcedar (*Thuja plicata*) forests. The AE study area was more rugged and dominated by extensive stands of unlogged forest, particularly at higher elevations. Habitats at lower elevations were dominated by Western Hemlock and Western Redcedar while species at higher elevations included Mountain Hemlock (*Tsuga mertensiana*) and Yellow Cedar (*Chamaecyparis nootkatensis*). Understory vegetation on both study areas was typically dense and consisted of Salal (*Gaultheria shallon*), ferns (several genera) and *Vaccinium* species communities. Both study areas had cool summers and mild winters, with temperatures of 0-10°C for 4-6 months/year and annual precipitation of 1700-5000 mm/year (Meidinger and Pojar 1991). AE was cooler and wetter, with a greater proportion of precipitation falling as snow.

Cougars were captured between 4 March 1991 and 1 September 1996 at NWB and from 18 April 1997 to 12 September 1998 at AE. Local houndsmen were contracted to track and tree Cougars. Treed Cougars that could safely be immobilized were darted with a mixture of ketamine hydrochloride (3 mg/kg estimated total weight) and medetomidine hydrochloride (0.1 mg/kg). Cougars were sexed, measured (see below), and aged according to tooth replacement and wear, and by gum recession (Ashman et al. 1983; Laundré et al. 2000). Adult Cougars were fitted with VHF radio collars (Telonics, Inc., Mesa, AZ). Immobilizations were reversed with atipamezole (0.15 mg/kg). Morphological data from hunter-killed Cougars in and near AE were also included in our analyses.

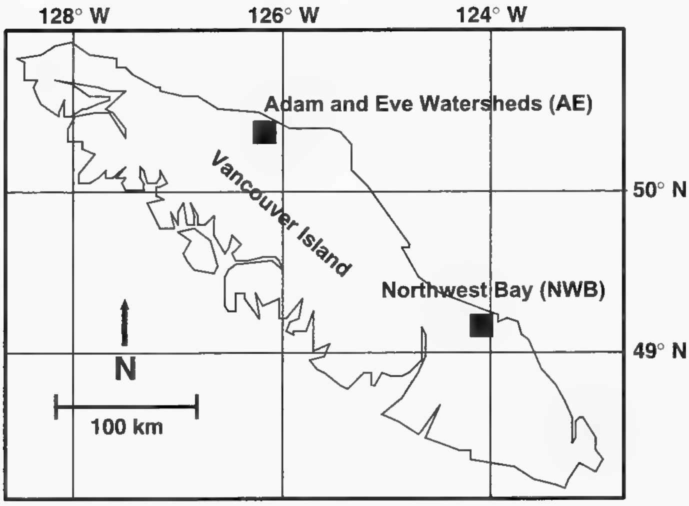

FIGURE 1. Location of cougar study areas on Vancouver Island, British Columbia, Canada.

Morphological measurements taken included: total weight (using a 100 kg spring balance to the nearest 1 kg), neck circumference at the base of the skull, chest circumference immediately behind the front legs, body length from nose to base of tail, tail length from base to tip of the last vertebrae (all to the nearest cm with a cloth tape measure), canine length from gumline to tip, and front and rear pad widths (to the nearest mm with a cloth tape measure; AE only).

We used principal component analysis (PCA) to derive a single variable to represent body size, based on the correlation matrix of morphological variables (Statistica 1995). We used this body size measure instead of total weight to describe the size of Cougars because it was less condition-dependent that using total weight alone. Where Cougars were captured >1 time, we included data from only the most recent capture. We used an analysis of covariance to test for differences in body size (log-transformed) between sex and study area, using age as a covariate. We also calculated means (±2 SE) for each morphological variable (by sex), but excluded Cougars <2 years old to minimize skews in distributions caused by the smaller body sizes of juvenile Cougars.

We calculated survival estimates with the staggered entry design of Pollock et al. (1989), which is based on the Kaplan-Meier product limit estimator (Kaplan and Meier 1958). This method estimates annual survival rate as the product of weekly survival rates ($1 - d/r$), where d is the number of animals that die and r is the number of animals "at risk" in a weekly period. Cougars carrying functioning radio collars comprised the "at risk" sample for each week. The design was "staggered entry" because not all Cougars carried collars at the same time. Cougars were added to the weekly sample as they were collared, and were removed as they died, had their collars removed, or when their collars stopped functioning. Analysis started with the collaring of the first Cougars in the two study areas. Annual survival estimates were based on 52 consecutive, seven-day periods.

There were sufficient data to analyse adult female Cougar survival; however, sample sizes were small, and the length of the study was relatively short in relation to the life expectancy of Cougars. Therefore, our estimates should be interpreted with caution.

We report the reproductive characteristics of collared females anecdotally because data were insufficient to calculate population growth rates; specifically, we had few data on birth intervals and survival to maturity. We report litter sizes (±2 SE) when they were first seen, so litter sizes at birth may have been larger, although in at least three litters, kittens were seen when <10 days old (eyes not open).

Results

Thirty Cougars were measured at NWB (17 females and 13 males) and 26 at AE (15 females and 11 males).

We used total weight, neck and chest circumference, and total length (body length + tail length) in the final PCA to derive a body size variable. All four variables loaded strongly and positively on the first axis, which explained 83% of the variation in the dataset. As a result, we used the first PCA axis as the index of body size (Table 1). We did not include canine length and body and tail lengths as separate variables in the analysis because doing so did not significantly increase the variation described in the first axis.

Body size differed between males and females ($P < 0.000$), but not between study areas ($P = 0.736$; Figure 2). Differences between males and females were also evident in univariate means of the morphological measurements (Table 2).

Mean survival rates were similar for collared Cougars on both study areas (Table 3). Known causes of female mortality at NWB included intraspecific killings (2) and animal control (3). The cause of one female mortality at NWB and both female mortalities at AE were unknown. Two mortalities of collared male

TABLE 1. Correlation between morphological variables and the first principal component axis (also known as "factor loadings"). The axis (based on the correlation matrix) was used as an index to describe body size of Vancouver Island Cougars in subsequent analyses.

Factor loadings of morphological variables					
Total Weight	Neck	Chest	Body length	Eigenvalue	% variation explained
0.994	0.889	0.927	0.878	3.314	82.8

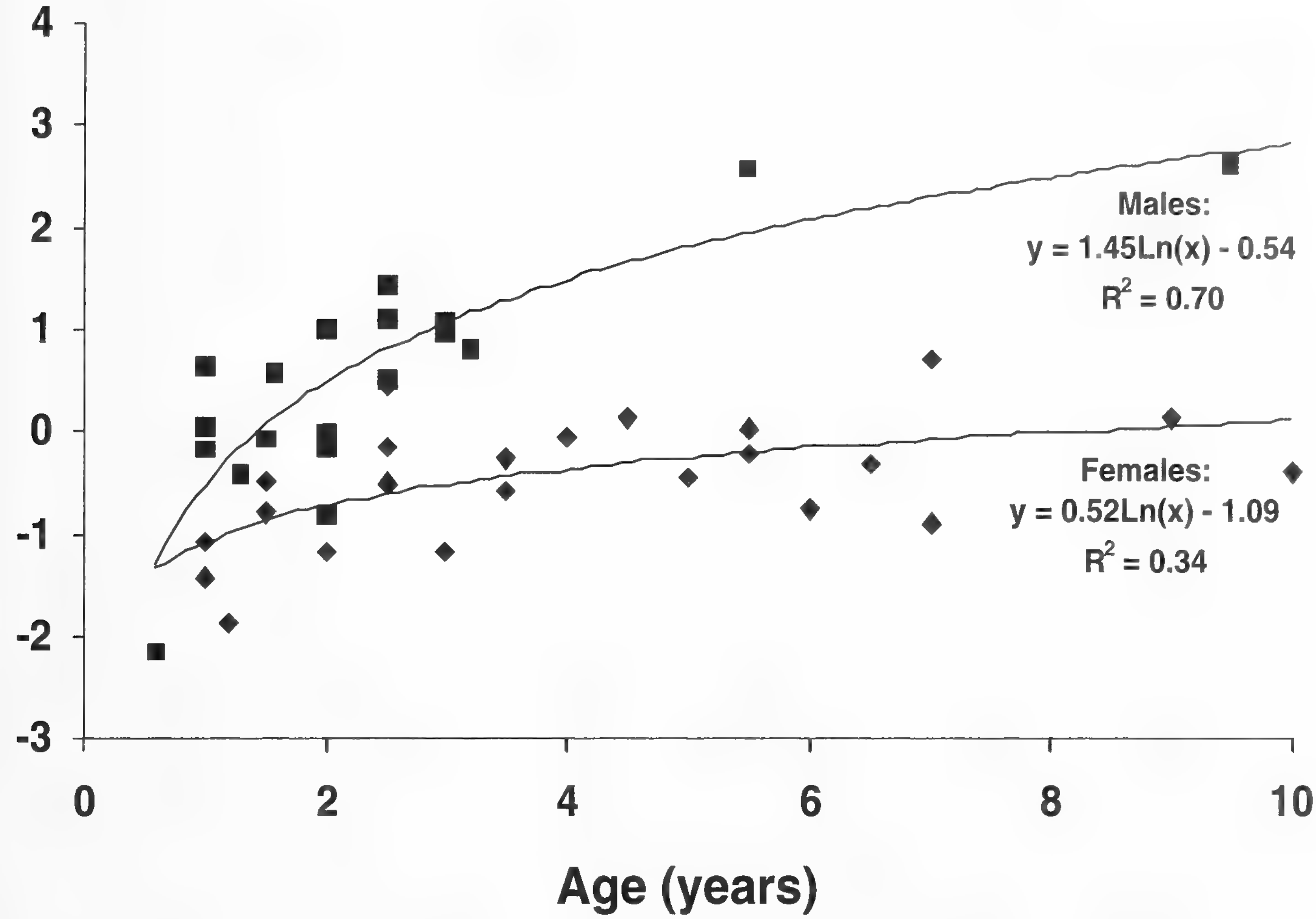

FIGURE 2. Relationship between body size (derived from the principal component analysis on morphological measurements, see text) and age for male and female Cougars in the two Vancouver Island study areas. Logarithmic trend lines are presented for males (squares ■) and females (diamonds ◆), pooled by study area. The body size measurement was used because it was less condition-dependent than using total weight alone.

Cougars were investigated at AE; one was shot by hunters and the other was suspected to have been shot illegally.

At NWB, mean litter size at first detection was 1.9 ± 0.1 (n = 16). One female was known to have a litter of three kittens, and there were 12 other litters of two kittens and 3 of one kitten when first observed. Females were known or suspected to give birth during all months from March-October. Consecutive litters were recorded for two females; each had litters 21 and 23 months apart.

Litter size at AE was 1.8 ± 0.7 (n = 5). There was one litter of three, and two litters each of one and two kittens. Females gave birth in January, August, and September. No collared females at AE had more than one litter during the study period.

Discussion

Results presented in this paper are based on small absolute sample sizes; however, Cougars are rare and secretive, and inferences about their morphology and behaviour must often be based on few animals. The

TABLE 2. Means and standard errors of morphological measurements taken on captured Vancouver Island Cougars.

Measurement	Males			Females		
	n	Mean	2 SE	n	Mean	2 SE
Total Weight (kg)	13	51.3	5.7	22	39.1	2.1
Neck (cm)	12	39.5	3.0	23	35.1	1.3
Chest (cm)	12	72.5	3.5	23	65.4	1.6
Body length (cm)	13	128.2	6.6	23	120.9	3.1
Tail Length (cm)	13	73.0	4.5	23	70.1	2.3
Front pad Width (mm)	9	57.9	1.9	12	51.1	2.2
Hind pad Width (mm)	9	50.4	3.3	12	37.9	9.1
Canine Length (mm)	10	28.6	1.5	23	26.8	2.0

TABLE 3. Annual and mean survival rates of female Vancouver Island Cougars collared in two study areas: Northwest Bay (NWB) and Adam and Eve rivers (AE). Annual estimates were based on a staggered-entry design, starting with the first Cougars collared at NWB and AE in March 1991 and April 1997, respectively.

Study Area	Year	*n*	Survival	-2 SE	+2 SE	Mean
NWB	1991-1992	4	1			
	1992-1993	7	1			
	1993-1994	7	0.75	0.47	1	
	1994-1995	7	0.82	0.56	1	
	1995-1996	7	0.88	0.64	1	0.89
AE	1997-1998	7	0.80	0.53	1	
	1998-1999	7	1			
	1999-2000	4	0.83	0.50	1	0.88

densities of Cougars in our study areas also suggest that significant proportions of the populations were captured (2.6-7.3 Cougars/100 km^2 at NWB and 1.4-2.0 Cougars/100 km^2 at AE; S. Wilson, unpublished data). Our sample sizes were similar to, or larger than, those in many comparable studies (e.g., n = 22, Hemker et al. 1984; n = 68, Ross and Jalkotzy 1992; n = 76, Lindzey et al. 1994; n = 34, Spreadbury et al. 1996; n = 13, Franklin et al. 1999; n = 21, Pierce et al. 2000).

Few researchers have published Cougar morphological characteristics (*c.f.* Kohlmann and Green 1999; Grigione et al. 2002); however, mean measurements of Vancouver Island Cougars in this study were smaller than those reported by Cowan and Guiguet (1965) for 14 adult male (mean total length 241 cm, tail length 89 cm, mean total weight 73 kg) and 7 adult female (mean total length 206 cm, tail length 79 cm, mean total weight 46 kg). Vancouver Island Cougars are slightly smaller than those found elsewhere in British Columbia (Cowan and Guiguet 1965).

Survival estimates are critical for population management, but few studies report them. Using the same method and similar sample sizes, Lindzey et al. (1988) reported mean survival rates (S = 0.731) for female Cougars in a largely unhunted population in southern Utah that were lower than those we calculated for Vancouver Island Cougars (mean for both study areas S = 0.885). Hunting is an important component of mortality in Cougar populations where hunting is allowed (Hemker et al. 1984; Logan et al. 1986; Ross and Jalkotzy 1992). The Vancouver Island population is no exception; however, we were in frequent contacts with hunters in our study areas and know they often treed radio-collared cougars but chose not to shoot them, even though we did not request this. This might have inflated the survival rates calculated for radio-collared Cougars. Researchers and managers should be aware of this bias when calculating survival estimates from similar radio telemetry studies where hunters "lend a hand" by not shooting study animals.

Animal control by British Columbia Wildlife Branch Control Officers was a significant source of human-caused mortality at NWB, where the human population density was higher than at AE. Intraspecific killing has been reported as an important source of mortality elsewhere (Lindzey et al. 1988; Spreadbury et al. 1996), but in our study it was detected only at NWB where Cougar population density was significantly higher than at AE.

Litters in both of our study areas were smaller than those reported in southeastern British Columbia ($\bar{x}$ = 3.1; Spreadbury et al. 1996), southwestern Alberta ($\bar{x}$ = 2.2; Ross and Jalkotzy 1992), Wyoming ($\bar{x}$ = 2.7; Logan et al. 1986), and southern Utah ($\bar{x}$ = 2.4; Lindzey et al. 1994). Other studies have recorded births in most months of the year (Ross and Jalkotzy 1992; Lindzey et al. 1994), with a peak in late summer and early fall (Lindzey et al. 1994). Our observations at AE were similar. The pattern was different at NWB, with no births recorded in winter and no obvious peaks in births during the spring-fall period.

Columbia Black-tailed Deer (*Odocoileus hemionus columbianus*) are the Vancouver Island Cougars' primary prey. Indices of deer abundance declined 55% from 1991-1996 at NWB and 38% from 1995-1999 at AE (British Columbia Ministry of Environment, Lands and Parks, unpublished data); therefore, small litter sizes among Vancouver Island Cougars may be a result of low food availability. Also, Black-tailed Deer are smaller than mainland Mule Deer (*Odocoileus hemionus*; Shackleton 1999). This highlights the importance of maintaining prey populations in management of Cougars on Vancouver Island.

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Conservation Evaluation of Lemmon's Holly Fern, *Polystichum lemmonii*, a Threatened Fern in Canada*

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Douglas, George W. 2004. Conservation evaluation of Lemmon's Holly Fern, *Polystichum lemmonii*; a threatened fern in Canada. Canadian Field-Naturalist 118(2): 164-168.

In Canada, Lemmon's Holly Fern, *Polystichum lemmonii*, is restricted to the Baldy Mountain area on the eastern side of the Okanagan River valley in south-central British Columbia. This population represents the northern limits of the species which ranges south through northern Idaho, Washington and Oregon to northern California. In British Columbia, *P. lemmonii* is associated with ultramafic rocky ridges within a montane forest at an elevation of 1900 m. The population in the Baldy Mountain area is relatively small, unprotected and potentially imperilled by mining exploration, forest road construction or wildfires.

Key Words: Lemmon's Holly Fern, *Polystichum lemmonii*, threatened, distribution, population size, British Columbia.

Lemmon's Holly Fern, *Polystichum lemmonii* Underw. [taxonomy and nomenclature follow Douglas et al. (1998a, b; 2000)], is a member of a cosmopolitan genus of over 175 species (Smith and Lemieux 1993; Wagner 1993). It is one of eight *Polystichum* species occurring in British Columbia (Ceska 2000) and nine occurring in Canada (Cody and Britton 1989; Wagner 1993). Generally, American authors treated *P. lemmonii* as a synonym of *P. mohrioides* (Bory) C. Presl. until Wagner (1979) demonstrated that the North American plant was different from the South American plant. *Polystichum lemmonii* was first recorded in Canada by Cody and Britton (1984).

Polystichum lemmonii is an evergreen, perennial, tufted fern arising from a short, stout rhizome (Figure 1; Ceska 2000). The decumbent to ascending fronds are 10-40 cm long, 3-7 cm wide and 2-pinnate. The 20-35 pinnae on each side of the rachis are ovate with rounded pinnules. The ultimate segments are entire or weakly toothed. The round sori are attached near the midvein with entire or minutely toothed indusia.

In British Columbia, *P. lemmonii* may be confused with either Kruckeberg's Holly Fern (*P. kruckebergii*) or Mountain Holly Fern (*P. scopulinum*). It may be

FIGURE 1. Illustration of *Polystichum lemmonii* (line drawing from Ceska 2000).

* The field work for the *Polystichum lemmonii* project was funded by the British Columbia Conservation Data Centre. The results appear in the British Columbia Conservation Data Centre database and a rare plant manual (Douglas et al. 2002). This information formed the basis for a Committee on the Status of Endangered Wildlife in Canada status report (Douglas 2003*) and the subsequent assessment of *threatened* (COSEWIC 2003*). The present paper also includes more recent information that will be used in a National Recovery Strategy for *P. lemmonii* (Douglas 2005).

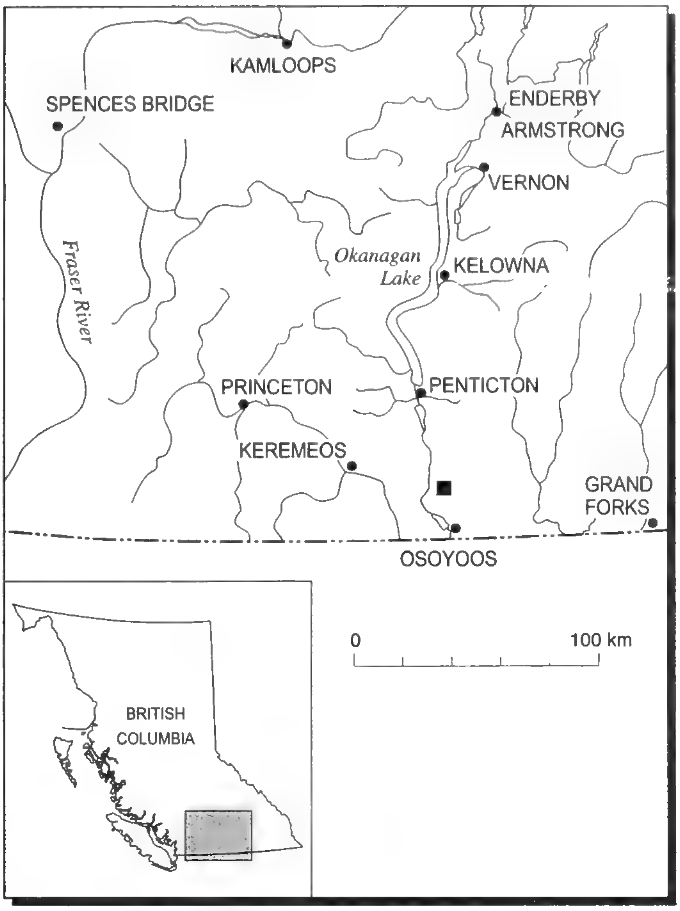

FIGURE 2. The small square indicates the location of *Polystichum lemmonii* in British Columbia.

distinguished from the latter two species by the lack of spines on the teeth of the ultimate segments of the pinnae (Hitchcock et al. 1969; Wagner 1993; Ceska 2000).

North American and Provincial Ranges

Polystichum lemmonii ranges from south-central British Columbia, sporadically south through Washington and Oregon to northern California (Smith and Lemieux 1993; Wagner 1993). In Canada, it is known only from the Baldy Mountain area in the Okanagan River valley in south-central British Columbia (Figure 2; Ceska 2000; Douglas et al. 2002).

Habitat

In western North America, *Polystichum lemmonii* occurs on sites where ferromagnesian or ultramafic rocks outcrop (Kruckeberg 1969; Wagner 1993). There are a number of ultramafic rock outcrops in western British Columbia but only the two small, adjacent ridges, at an elevation of 1900 m, in the Baldy Mountain area support the latter species (Figure 3). These dunite rock outcrop habitats are also characterized by shallow soils thus creating xeric microclimates that exclude many nearby species adapted to more mesic microclimates or non-ultramafic soils (Figure 4). These ridges, therefore, have a typically depauperate ultramafic flora and lack a tree cover in contrast to the

FIGURE 3. Aerial view of the ultramafic east ridge. Most *Polystichum lemmonii* plants occur on the north side of these east-west oriented ridges. The west ridge is slightly longer.

surrounding montane forests. The most prominent species on the ridge include Common Juniper (*Juniperus communis*), Indian's Dream (*Aspidotis densa*), Alpine Sandwort (*Minuartia obtusiloba*) and Yarrow (*Achillea millefolium*).

Biology

There is a limited amount of information on the biology and ecology of *Polystichum lemmonii*. The ultramafic habitat, however, has been well-studied by Kruckeberg (1969). Plants of ultramafic substrates are adapted to tolerate low levels of calcium, nitrogen, phosphorus and molybdenum and high levels of magnesium, chromium and nickel (Kruckeberg 1969).

Wagner (1979) has provided some genetic information. *P. lemmonii* is a tetraploid (2n = 82) and thought to be one of the parents of both *P. kruckebergii* and *P. scopulinum*.

Sporophytes of *P. lemmonii*, as with most evergreen fern species, often retain significant numbers of mature spores over the winter that are then released the following spring (Farrar 1976). *P. lemmonii* also grows vegetatively by subterranean rhizome elongation often resulting in large clumps of clones. Because of the dry site conditions, which are not ideal for spore germination or gamete fertilization, most reproduction is probably by rhizome elongation (Walker 1979). Prothalli were not observed at the site.

Long-distance dispersal of spores of *P. lemmonii* is evident by the distance to the nearest locations of the species in the adjacent state of Washington in the United States. *P. lemmonii* occurs in the Twin Sisters Range of Washington and in the Wenatchee Mountains (Kruckeberg 1969), a distance of about 205 km to the southwest and 225 km to the south of Baldy Mountain, respectively. The Tulameen River ultramafic site, where both *P. kruckebergii and P. scopulinum* occur (Kruckeberg 1969; Douglas and Labrecque 2003*), does not contain *P. lemmonii* even though the Tulameen River site is halfway between Baldy Mountain and the Twin Sisters Range. Reproduction of *P. lemmonii* at the Baldy Mountain area is evident since about 30 percent of the 853 plants counted were relatively young (plant tufts less than four cm wide).

Population Attributes

The population of *P. lemmonii* occurs on two adjacent, rocky ridges. The ridges, which are about 280 and 200 m long by 50 m wide, are separated by a distance of 160 m. A 2001 count of all plants in the population by the author revealed a total of 853 plants over 0.72 ha. A collection by D. M. Britton in 1987 (at Department of Agriculture, Ottawa) mentions a population size of "perhaps a thousand plants". This would indicate that the population has remained relatively stable for at least 15 years.

Provincial, National and Global Ranks

The British Columbia Conservation Data Centre has ranked this species as S1 and placed it on the British Columbia Ministry of Sustainable Resource Management Red-list (Douglas et al. 2002). This is the most critical category for imperilled rare native vascular plants in British Columbia. A rank of S1 is considered "critically imperilled because of extreme rarity (5 or fewer occurrences or very few remaining individuals) or because of some factors making it especially vulnerable to extirpation or extinction" (Douglas et al. 2002). Since the species is restricted to British Columbia, the National rank is N1. Globally, *Polystichum lemmonii* is ranked G4 and is frequent to common in its range and apparently secure.

Threats and Protection

The most direct threat to *Polystichum lemmonii* is mining exploration. At the present time the entire area is occupied by active mining claims and exploration could occur with short notice. Additional threats include the potential use of the rock outcrop for forest road construction and the possibility of intense wildfires. Extremely high forest fuel loads in the the area may lead to wildfires similar to that experienced in the region in 2003. Introduced species are of no concern at this site due to the ultramafic properties of the soils.

The population in the Baldy Mountain area is on public land but is not part of a protected area. It is conceivable that this area could qualify as a Wildlife Habitat Area but this status has yet to be proposed. *Polystichum lemmonii* could be a candidate species for protection under the provincial *Wildlife Amendment Act* as it is currently Red-listed by the British Columbia Conservation Data Centre.

Evaluation

The British Columbia Conservation Data Centre considers *Polystichum lemmonii* to be threatened/endangered in British Columbia (Douglas et al. 2002) and the Committee on the Status of Endangered Wildlife in Canada has assessed the species as threatened (COSEWIC 2003). Just over 850 plants are known from a single site in Canada at the Baldy Mountain area of south-central British Columbia. The prognosis for this species is not good since ultramafic rock outcrops often attract mineral exploration and the entire area is covered by active mineral claims. These rock outcrops could also be of potential use as a quarry for road building materials. The extremely high forest fuel loads in the adjacent area could also support wildfires. Establishment of a Wildlife Habitat Area and removal of the active mineral claims would remove the major threats at the site.

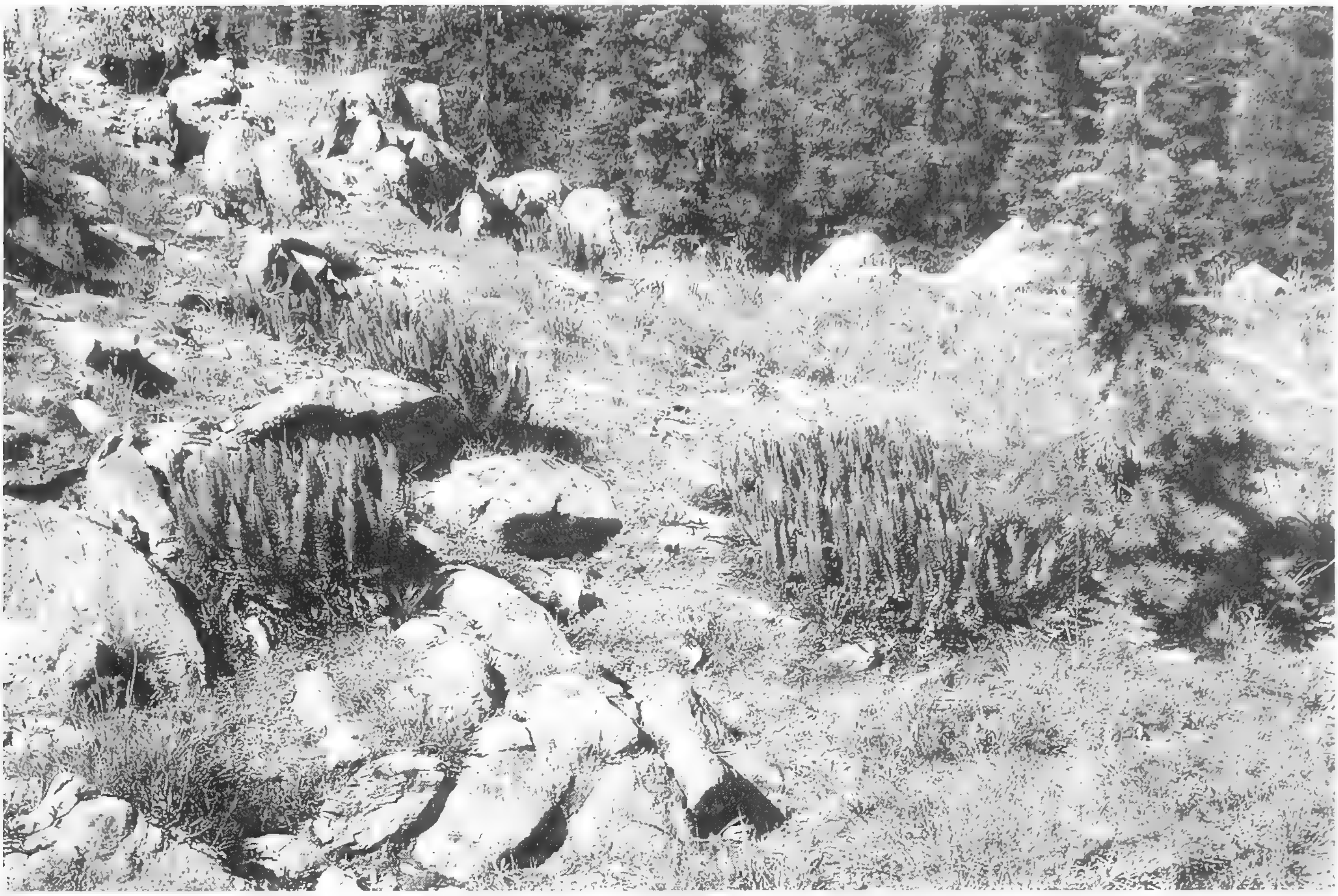

FIGURE 4. *Polystichum lemmonii* plants are conspicuous among the low vegetation on the ultramafic soils.

Acknowledgments

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Conservation Evaluation of the Pacific Population of Tall Woolly-heads, *Psilocarphus elatior*, an Endangered Herb in Canada*

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Douglas, George W., and Jeanne M. Illingworth. 2004. Conservation evaluation of the Pacific population of Tall Woolly-heads, *Psilocarphus elatior*, an endangered herb in Canada. Canadian Field-Naturalist 118(2): 169-173.

In Canada, *Psilocarphus elatior* occurs in British Columbia, Alberta and Saskatchewan. This paper examines the status of the Pacific populations located on southeastern Vancouver Island in southwestern British Columbia. The Pacific population consists of 12 recorded sites of which only five have been confirmed since 1993. In British Columbia, *P. elatior* is associated with dried beds of vernal pools and other open, moist depressions at lower elevations. In British Columbia, *P. elatior* populations occur in large numbers at only two of the seven locations.

Key Words: Tall Woolly-heads, *Psilocarphus elatior*, endangered, distribution, population size, British Columbia.

Tall Woolly-heads, *Psilocarphus elatior* (A. Gray) A. Gray[2] [Taxonomy and nomenclature follows Douglas (1998) and Douglas et al. (1998; 1999a, c; 2001a b), is a member of a genus of five species which occur in the Americas (Cronquist 1950). It is one of three species occurring in British Columbia and Canada (Douglas 1998).

Psilocarphus elatior is a small, erect, annual plant up to 15 cm tall (Figure 1; Douglas 1995, 1998). The opposite leaves are silky-hairy, linear-oblong, entire on the margins and 1.2 to 3.5 mm long. The flowers form solitary spherical heads in the leaf axils or at the tips of the stems or leaf branches. The flowers lack involucres but have involucral-like leaves at their bases. Each of the outer (female) threadlike ray flowers has a well developed, 2.4 to 3.8 mm long receptacle bract. These bracts have a translucent appendage below the summit.

In British Columbia, *P. elatior* may be distinguished from Slender Woolly-heads (*P. tenellus* var. *tenellus*) by its erect habit, larger heads and receptacular bracts. In the field, young specimens of *P. elatior* may also be confused with young specimens of Lowland Cudweed (*Gnaphalium palustre*). Close examination will reveal that most of the leaves of the latter are alternate and the flower heads have densely woolly involucres, broader ray flowers and a non-spherical shape.

North American and Provincial Ranges

Psilocarphus elatior ranges from southwestern British Columbia, southeastern Alberta and southwestern Saskatchewan in Canada, south through Idaho, Washington and Oregon to northern California (Cronquist 1955; Scoggan 1979; Morefield 1993; Douglas 1998). In British Columbia, it is restricted to south-eastern Vancouver Island in south-western British Columbia (Figure 2; Douglas 1998; Douglas et al. 2002).

Habitat

Psilocarphus elatior inhabits dried beds of vernal pools, ephemeral lake edges (Figure 3) and other open moist, often disturbed sites at lower elevations. The sites are often level and generally slightly depressed. *Psilocarphus elatior* is not found within particular communities and often occupies sites where other species are sparse. There does not appear to be a consistent association with other plants.

The Somenos Lake locality near Duncan supports the largest and most vigourous population of *P. elatior* (Table 1). The plants grow on the moist shoreline of the lake and appear when the lake level recedes in late spring or early summer. Major associates at this site include Slender-beaked Sedge (*Carex athrostachya*), One-sided Sedge (*C. unilateralis*), Brass Buttons (*Cotula coronopifolia*) and Skunkweed (*Navarretia squarrosa*).

At Uplands Park, in the Municipality of Uplands near Victoria, five subpopulations occur in a large ephemeral meadow. Associated species include Bentgrass (*Agrostis* sp.), California Oatgrass (*Danthonia*

* Field work for the *Psilocarphus elatior* project was funded by the British Columbia Conservation Data Centre. The results appear in the British Columbia Conservation Data Centre database and a rare plant manual (Douglas et al. 2002). These data formed the basis for a Committee on the Status of Endangered Wildlife in Canada status report (Douglas, et al. 1999b) and the subsequent assessment of *endangered* (COSEWIC 2004*) for the Pacific population. The present paper also includes more recent information from research funded by the British Columbia Conservation Data Centre.

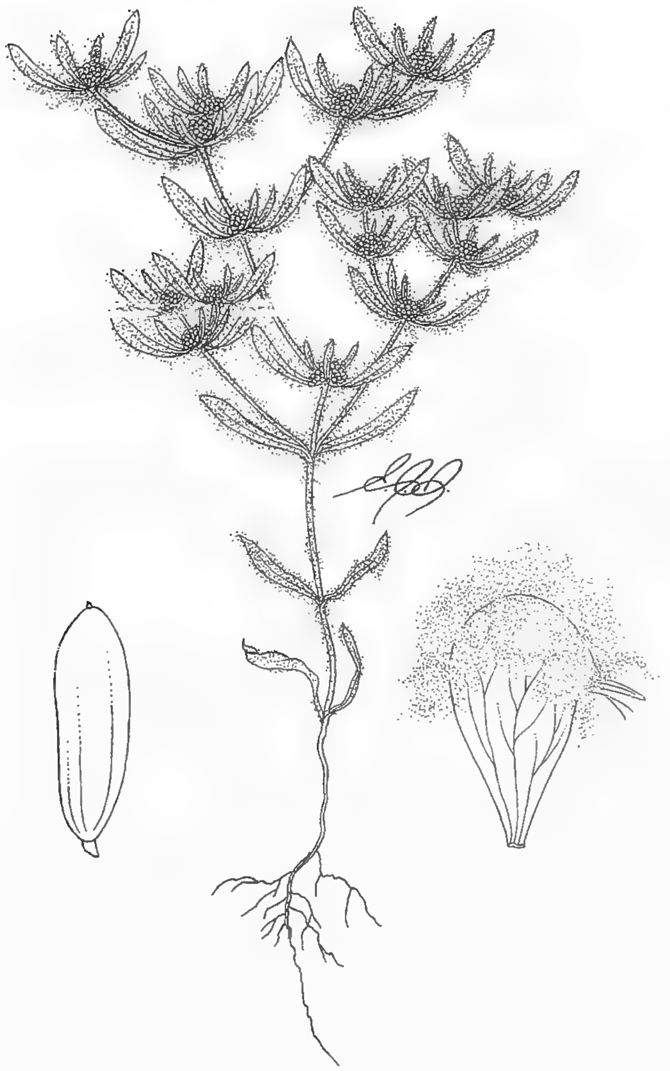

FIGURE 1. Illustration of *Psilocarphus elatior* (line drawing by Elizabeth J. Stephen in Douglas [1995, 1998]).

californica), Toad Rush (*Juncus bufonis*), Perennial Ryegrass (*Lolium perenne*) and Small Hop-clover (*Trifolium dubium*). Introduced species are more abundant here than at the Somenos Lake site and appear to be increasing yearly.

The Christmas Hill site, although smaller than the previous two sites, is in relatively good condition. Native species in this habitat include Carolina Meadow-foxtail (*Alopecurus carolinianus*), Green-sheathed Sedge (*Carex feta*), Heterocodon (*Heterocodon rariflorum*), and Scouler's Popcornflower (*Plagiobothrys scouleri*).

The two remaining populations, at Scafe Hill and Cattle Point, occur in small depressions. These populations are probably the least stable of the extant populations. The Cattle Point populations are absent during some years but the seed bank appears to remain.

Psilocarphus elatior is considered to be a vernal pool specialist (Keeley and Zedler 1998). They define vernal pools as "precipitation-filled seasonal wetlands inundated during periods when temperature is sufficient for plant growth, followed by a brief water-logged-terrestrial stage and culminating in extreme desiccating soil conditions of extended duration". The species is able to outcompete grassland species due to its tolerance of inundation and aquatic/wetland species due to its tolerance of soil desiccation and heat during summer drought.

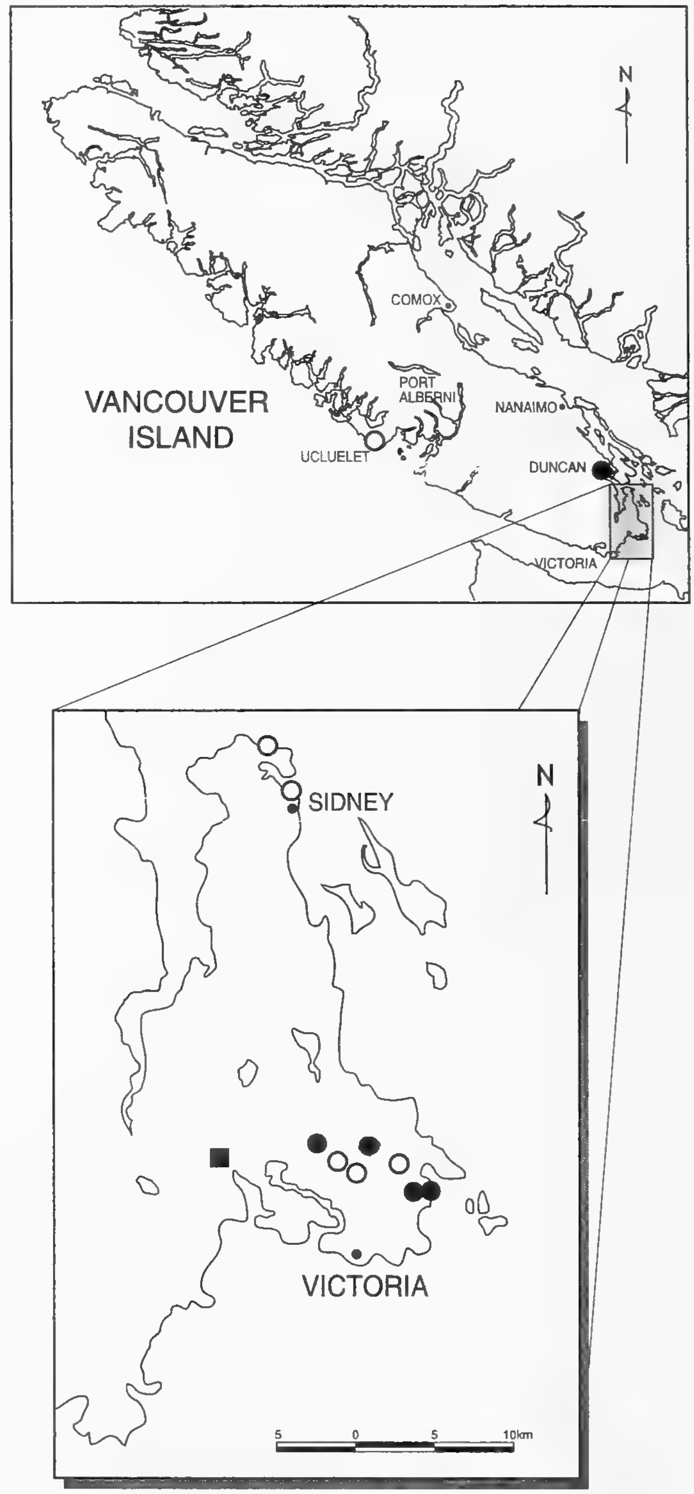

FIGURE 2. The location and status of *Psilocarphus elatior* sites in British Columbia (○ – extirpated sites, • – recently confirmed sites, ■ – present status unknown).

Biology

Other than general habitat information, there is little in the literature regarding the biology and ecology of *Psilocarphus elatior*. It is likely, however, that this plant shares many of the same traits that are typical of the genus.

FIGURE 3. A dense population of *Psilocarphus elatior* on the edge of Somenos Lake. The prominent sedge is *Carex athrostachya*. This site is usually submerged until late spring.

Lack of structures attractive to insects and animals, and an interpretation of the floral structure indicate these inconspicuous, woolly annuals may self-pollinate. Cronquist (1950) suggested that in the genus *Psilocarphus*, the position of the receptacular bracts, together with the position of the corolla and stigmas, effectively guide these latter structures towards the central flowers. Since it is the central flowers alone that produce pollen, and since the wool and leaves surrounding the head appeared to prevent pollen loss by wind, self-pollination is indicated. It is also possible that pollen may not be essential for seed-production and that asexual reproduction may be occurring, although chromosome counts would be necessary to verify this.

Seed dispersal also appears limited. Since the achenes are much smaller than the enclosing bracts, the only obvious means of dispersal is by water or wind.

Table 1. Locations and Population Sizes for *Psilocarphus elatior* in British Columbia.

Collection Site	Last Observation	Collector/ Observer	Population (no./area)
Cloverdale (Victoria)	1887	Macoun	Extirpated
Cedar Hill (Victoria)	1887	Macoun	Extirpated
Ucluelet	1909	Macoun	Extirpated
Roberts Bay (Sidney)	1913	Macoun	Extirpated
Swartz Bay (Sidney)	1931	Groh	Extirpated
Francis-King Regional Park (Victoria)	1962	Melburn	Unknown
University of Victoria (Victoria)	1966	Turner	Extirpated
Cattle Point, Uplands Park (Victoria)	1993	Ryan	200/10 m^2
Scafe Hill (Victoria)	1996	Roemer	20/? m^2
Uplands Park (Victoria)	1998	Douglas	40 000+/1 200+ m^2
Christmas Hill (Victoria)	2001	Douglas & Penny	450/72 m^2
Somenos Lake (Duncan)	2002	Douglas & Douglas	100 000+/45 m^2

The plant's habitat in vernal pools may also permit the bracts and achenes to be transferred by the muddy feet of waterfowl and other animals (Cronquist 1950).

Further studies are required to determine many aspects of the population dynamics of *P. elatior* including the average life-cycle of the species, the frequency and requirements for seed germination and survival, and its competitive ability with other species.

Population Attributes

Psilocarphus elatior has been recorded from 12 sites in southwestern British Columbia (Table 1). Five of these have been confirmed since 1993. The status of the remaining populations is unknown and many are believed extirpated. Population areas range from 10 m^2 to over 1200 m^2 while numbers of plants range from 20 to over 100 000. In the majority of cases, population trend analysis is not available because of limited demographic data.

Provincial, National and Global Ranks

Provincially, *P. elatior* is ranked S2 by the British Columbia Conservation Data Centre (Douglas et al. 2002) which indicates this species to be "imperiled because of rarity (typically 6–20 extant occurrences or few remaining individuals) or because of some factor(s) making it vulnerable to extirpation or extinction." Nationally the species is ranked N3, while globally it has a rank of G5. The latter rank indicates it is "frequent to common to very common; demonstrably secure and essentially ineradicable under present conditions".

Threats and Protection

Habitat destruction is the greatest threat to the existing populations of *Psilocarphus elatior*. Some sites occur in areas subjected to heavy pedestrian trampling or are at risk from private development. Threats to the continued survival of this species are compounded by the lack of biological and ecological information which create difficulties in site management.

Four of the *P. elatior* populations are partially protected by their location in municipal or regional parks or special protected areas (Somenos Lake). The latter probably has the greatest degree of protection since it is administered by British Columbia Parks and falls under the *Park Act*. Most of the municipal or regional parks receive little active management at the present time, at least with respect to their rare plants. Park enhancement projects, road and trail developments and heavy recreational use by humans often result in the destruction of the native vegetation and rare plant species. *Psilocarphus elatior* could be a candidate species for protection under the provincial *Wildlife Amendment Act* as it is currently Red-listed by the British Columbia Conservation Data Centre (Douglas et al. 2002).

Most of the populations contain small numbers of plants. Once a population becomes small, it becomes more susceptible to demographic and environmental variation and loss of genetic variability. In some cases, small populations are at risk of inbreeding depression, genetic drift and loss of fitness (Primack 1998).

Evaluation

The British Columbia Conservation Data Centre considers *Psilocarphus elatior* to be threatened/endangered in British Columbia (Douglas et al. 2002a) and the Committee on the Status of Endangered Wildlife in Canada has assessed the species as endangered (COSEWIC 2003). Most of the populations are small and not viable. With limited knowledge of the plants biological and ecological requirements, this species is vulnerable to extirpation in British Columbia. Without research on growth requirements and further demographic information, the stability of the present populations will remain unknown. Studies are also necessary to determine if the present habitats are necessary for the successful growth of *P. elatior* or if these plants are simply outcompeted elsewhere. The limited number of individuals also reduces the potential for genetic variation which may be necessary to respond to environmental changes in the future.

Acknowledgments

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Conservation Evaluation of Howell's Triteleia, *Triteleia howellii*, an Endangered Lily in Canada*

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Douglas, George W., and Jenifer L. Penny. 2004. Conservation evaluation of Howell's Triteleia, *Triteleia howellii,* an endangered lily in Canada. Canadian Field-Naturalist 118(2): 174-178.

In Canada, *Triteleia howellii* is restricted to *Quercus garryana* stands and grass-dominated meadows on southeastern Vancouver Island in southwestern British Columbia. Nine sites have been confirmed in recent years while three other sites are considered extirpated. These Canadian sites represent the northern range limits of *T. howellii*. Threats to existing populations vary in intensity. Although most populations are protected to a certain extent from direct habitat destruction, introduced species pose a serious potential threat to the continued existence of most populations. Managing sites for *T. howellii* is difficult because little information is available regarding the general biology of this species.

Key Words: Howell's Triteleia, *Triteleia howellii*, endangered, distribution, population size, British Columbia.

Howell's Triteleia, *Triteleia howellii* (S. Wats.) Greene [taxonomy and nomenclature follow Douglas et al. (1998a, b; 1999a, b; 2000, 2001a, b)], sometimes treated as *T. grandiflora* Lindl. var. *howellii* (S. Wats.) Hoover, is a member of a genus of 14 species in North America (Keator 1993). Three species occur in British Columbia and Canada (Scoggan 1979; Pojar 2001).

Triteleia howellii is a perennial herb from a deep, straw-coloured, fibrous-scaly, nearly globe-shaped, bulb-like corm (Figure 1; Pojar 2001). The erect, flowering stem is 20-50 cm tall with one or two smooth, slender, linear basal leaves. The leaves are 20-40 cm long, 3-8 mm wide, sheathed at the base and have entire margins. The flowers consist of six whitish to blue, vase-shaped to narrowly bell-shaped, fused segments forming a 1.5-2 cm long tube. The corolla lobes, which are about as long as the tube, are in two, spreading, petal-like whorls, about as long as the tube. The outer three are broadly lanceolate, the inner three are oblong-egg-shaped and all are slightly ruffled. The fruit consists of a stalked, egg-shaped capsule containing black rounded seeds.

Triteleia howellii is similar in appearance to its close relative *T. grandiflora.* It is distinguished from the latter by its flat filaments which are attached at the same level on the perianth tube (Pojar 2001). The filaments of *T. grandiflora*, in contrast, are not flat and are attached at two levels on the perianth tube.

* The field work for the *Triteleia howellii* project was funded by the British Columbia Conservation Data Centre. The results appear in the British Columbia Conservation Data Centre database and a rare plant manual (Douglas et al. 2002). This information formed the basis for a Committee on the Status of Endangered Wildlife in Canada status report (Douglas 2003*) and the subsequent assessment of *Endangered* (COSEWIC 2003*). The present paper also includes more recent information, funded by the Nature Conservancy of Canada and the Habitat Conservation Trust Fund, that will be used in a National Recovery Strategy for *T. howellii* (Douglas and Smith 2005).

North American and Provincial Ranges

Triteleia howellii ranges from southwestern British Columbia, south through Washington and Oregon to northern California (Barkworth 1977a; Keator 1993). In Canada, *T. howellii* is known only from southeastern Vancouver Island (Figure 2; Pojar 2001; Douglas et al. 2002).

Habitat

In British Columbia *T. howellii* occurs on rock outcrops, in Garry Oak (*Quercus garryana*) woodlands, Garry Oak/Arbutus (*Arbutus menziesii*) stands and occasionally in highly disturbed sites dominated by weeds in private yards and on roadsides. In the highly disturbed sites, dominants include Orchard Grass (*Dactylis glomerata*), Cheat Grass (*Bromus tectorum*), Common Vetch (*Vicia sativa*), Rip-gut Brome (*Bromus rigidus*), Soft Brome (*B. hordeaceus*), Perennial Ryegrass (*Lolium perenne*), and Pacific Sanicle (*Sanicula crassicaulis* var. *crassicaulis*), all introduced except for *Sanicula*.

At the highest quality site, in the *Quercus garryana* woodland at the Cowichan Garry Oak Preserve, the habitat is classified as a *Quercus garryana/Dactylis glomerata* plant community (Douglas et al. 2002*) and is characterized by deep, dark soils up to a metre in depth. It is likely that prior to understory dominance by *D. glomerata* in this (Figure 3), and other *Quercus* stands of the region, this plant community would have fallen within the *Q. garryana*/California Brome (*Bromus carinatus*) community type (Roemer 1972). An

FIGURE 1. Illustration of *Triteleia howellii* (Line drawing in Pojar 2001).

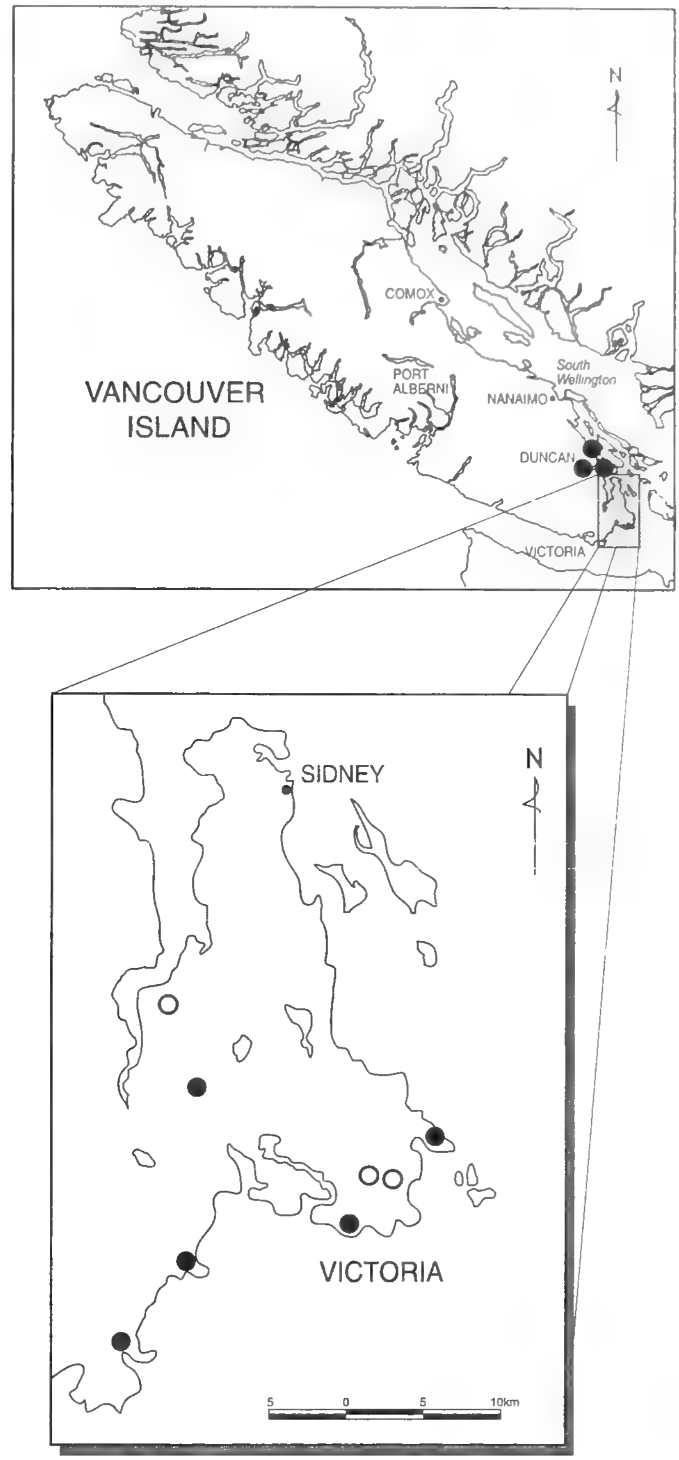

FIGURE 2. Distribution of *Triteleia howellii* in British Columbia (○ – extirpated sites, ● – recently confirmed sites).

extremely rich low shrub and herb stratum is present during the spring. The most prominent species in the Cowichan Garry Oak Preserve Garry Oak stand are *Sanicula crassicaulis* var. *crassicaulis* and *Dactylis glomerata* (Douglas et al. 2002*). Other species with moderate to high constancies associated with *T. howellii* include Common Camas (*Camassia quamash*), *Bromus* spp., Broad-leaved Shooting-star (*Dodecatheon hendersonii* ssp. *hendersonii*), Cleavers (*Galium aparine*), and Common Snowberry (*Symphoricarpos albus*). A marked change in composition takes place by mid-summer. Many of the conspicuous native plants (e.g., Great Camas (*Camassia leichtlinii*), *C. quamash*, *Dodecatheon hendersonii*, and Yellow Montane Violet (*Viola praemorsa* ssp. *praemorsa*)) have completed their yearly life cycle and have essentially disappeared. Perennial grasses that were not recognizable or had not initiated growth in the spring and numerous intro-

TABLE 1. Locations and population sizes for *Triteleia howellii* in Canada

Collection Site	Last Observation	Collector/ Observer	Population (no./area)
Oak Bay (Victoria)	1912	Beaven	Extirpated
Saanich Arm (Victoria)	1919	Newcombe	Extirpated
Witty's Lagoon Regional Park (Metchosin)	1999	Douglas & Penny	43/200 m^2
Gordon Head (Saanich)	1999	Fontaine	51/5 m^2
Cowichan Garry Oak Preserve (Duncan)	1999	Douglas	430/3-4 ha
Cowichan River Estuary (Duncan)	2001	Douglas	62/3 m^2
Thetis Lake Regional Park (View Royal)	2002	Ceska	1/1 m^2
Uplands Park (Victoria)	2003	Penny & Fairbarns	Not seen since 1917, 2003 search unsuccessful, probably extirpated
Mt. Tzuhalem, base of (along Khenipsen Road)	2003	Janszen	6/.05 m^2
Albert Head Lagoon Regional Park (Metchosin)	2003	Roemer	8/2 m^2
Horth Hill Regional Park (North Saanich)	2003	Janszen	3/1 m^2
Beacon Hill Park (Victoria)	2004	Fairbarns	ca 200/12 m^2
Somenos Lake (Duncan)	2004	Douglas & Richards	90/140 m^2
Williams Head Road (Metchosin)	2004	Milne	14/?m^2

duced annuals, well adapted to the drier soils, dominate the understory. At this time, *Dactylis glomerata* and *Vicia* species are the most prominent species with greatly increased mean covers. Other prominent species in mid-summer include the native grasses, *Bromus carinatus* and Alaska Oniongrass (*Melica subulata*), and the introduced grasses, Barren Brome (*Bromus sterilis*) and Kentucky Bluegrass (*Poa pratensis*).

Triteleia howellii also occurs in a *Quercus garryana – Arbutus menziesii* stand. The shrub layer is more prominent at this site and is dominated by Tall Oregongrape (*Mahonia aquifolium*) and Oceanspray (*Holodiscus discolor*). Major associates include Hairy Honeysuckle (*Lonicera hispidula*), *Bromus rigidus*, *Galium aparine*, Small-flowered Nemophila (*Nemophila parviflora*) and Hedgehog Dogtail (*Cynosurus echinatus*).

Biology

There is little information known about the biology or ecology of *Triteleia howellii* throughout its range. Reproduction is by division of the corm, by production of numerous cormlets, and by seed (Barkworth 1977b).

Population Attributes

Triteleia howellii has been collected at 14 sites in Canada, all of which are located on southeastern Vancouver Island (Table 1). Of the 14 sites, 11 have been confirmed since 1999 while the status of the remaining three sites is unknown and are likely extirpated. Population areas range from small (one m^2) to over three or four hectares, while plant numbers range from a single plant to over 430 plants (Table 1). Little information is available on population trends. The sites that have recently been examined show the populations are apparently stable although numbers of flowering plants may vary.

Provincial, National and Global Ranks

The British Columbia Conservation Data Centre has ranked this species S2 and placed it on the British Columbia Ministry of Sustainable Resource Management red-list (Douglas et al. 2002). This is the most critical category for imperilled rare native vascular plants in British Columbia. A rank of S2 is considered "critically imperilled because of rarity (typically 6-20 extant occurrences or few remaining individuals) or because of some factor(s) making it vulnerable to extirpation or extinction." Since the species is restricted to British Columbia, the National rank is N2. Globally, *Triteleia howellii* is ranked G3G4, indicating that, although the presently known sites are less than 100, it is more likely that this species is frequent to common in its range and apparently secure.

Threats and Protection

The most direct and immediate threat to *Triteleia howellii* is habitat destruction. This is of particular concern in the grass-dominated meadows often associated with the *Quercus garryana* communities that are restricted to the southeastern side of Vancouver Island and some of the Gulf Islands. This type of vegetation was much more common before colonization by European settlers. This destruction has continued to the present resulting in the elimination of almost all sites occurring outside parks or ecological reserves. Historically, *Q. garryana* communities and grass-dominated meadows have always been heavily influenced by human activity, especially fires. Roemer (1972) believed that without human interference some of these stands would have eventually been replaced by Douglas-fir forests.

FIGURE 3. Habitat of *Triteleia howellii* in a *Quercus garryana* stand in the Cowichan Garry Oak Preserve near Quamichan Lake. *Dactylis glomerata* is the dominant grass in this late summer photo.

The suppression of fire within the past century may also have contributed to the decrease of *Triteleia howellii* populations. Most of the sites in which *T. howellii* has been collected were likely maintained in the past as a result of periodic fires, both natural and unnatural. In the past, aboriginal peoples probably set fire to these stands to maintain them as an important habitat for wildlife (Roemer 1972). Since that time, these sites have experienced little disturbance, resulting in the invasion and expansion of many other species, especially introducted grasses.

The introduction of European species has resulted in substantial, and probably irreversible, changes not only to the grass-dominated meadows associated with *Quercus garryana*, but also to the rocky xeric sites north and west of Victoria where *Triteleia howellii* has been collected in the past. One of the most devastating species is Scotch Broom (*Cytisus scoparius*), which has become a dominant shrub on xeric, exposed sites throughout much of southeastern Vancouver Island and the Gulf Islands. Much of the vegetation is now dominated by introduced grasses. These species include Early Hairgrass (*Aira praecox*), Sweet Vernalgrass (*Anthoxanthum odoratum*), *Cynosurus echinatus* and *Dactylis glomerata*.

Some of the populations contain very few plants. Once a population becomes small, it becomes more vulnerable to demographic and environmental variation and loss of genetic variability. In some cases, small populations are at risk of inbreeding depression, genetic drift and loss of fitness (Primack 1998).

The population with the best protection is located at the Cowichan Garry Oak Preserve where the general public is excluded. This five-hectare stand near Quamichan Lake on Vancouver Island represents the best example of a *Quercus garryana* woodland in the province and probably one of the best in the Pacific Northwest. The stand contains a relatively low number of exotic species and has active management plans in place. This site also contains the largest known population of *T. howellii* in the province (Douglas et al. 2002*).

A number of *Triteleia howellii* populations are also in small regional parks in the Greater Victoria area. These include populations at Beacon Hill, Witty's Lagoon, Thetis Lake, and Horth Hill. Most of these parks receive little active management at the present time, at least with respect to their rare plants. Park enhancement projects, road and trail developments and heavy recreational use by humans often result in the destruction of the native vegetation and rare plant species.

Triteleia howellii could be a candidate species for protection under the provincial *Wildlife Amendment*

Act as it is currently red-listed by the British Columbia Conservation Data Centre. One of the populations (Somenos Lake) of *T. howellii* is protected by the *Park Act* since it is currently administered by Parks BC.

Evaluation

The British Columbia Conservation Data Centre considers *Triteleia howellii* to be threatened/endangered in British Columbia (Douglas et al. 2002a) and the Committee on the Status of Endangered Wildlife in Canada has assessed the species as endangered (COSEWIC 2003). About 1000 flowering plants have been recorded in recent years from 11 locations. Only four of these populations can be considered viable since the remaining populations cover areas of less than 5 m^2. The prognosis for this species may not be good since, since only one population, at the Cowichan Garry Oak Preserve, is included in an active management plan.

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Conservation Evaluation of Small-flowered Lipocarpha, *Lipocarpha micrantha* (Cyperaceae), in Canada

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In Canada, *Lipocarpha micrantha* has been documented at eight locations in Quebec, Ontario, and British Columbia. Four of these populations have apparently been extirpated. The remaining populations, ranging from 120 to approximately 40000 plants, are all northern disjuncts from the main range of this species. Threats to these populations include water level regulation and shoreline development. Considering the threats to the habitat of *Lipocarpha micrantha*, and the small size of most of the remaining populations, it has been designated an Endangered species in Canada.

Key Words: Small-flowered Lipocarpha, *Lipocarpha micrantha*, British Columbia, Ontario, Quebec, endangered, distribution, population size.

Small-flowered Lipocarpha, *Lipocarpha micrantha* (Vahl.) G. Tucker, is the only member of a mainly tropical genus to occur in Canada. While it appears under this name in the *Flora of North America* (Tucker 2002), some recent treatments place it in the genus *Hemicarpha* Nees (Gleason and Cronquist 1991). *Lipocarpha*, including *Hemicarpha*, is generally accepted as a distinct genus. However, taxonomic clarification of closely related genera in the Cyperaceae may require nomenclatural revisions, pending the outcome of ongoing research (Muasya et al. 2002).

Lipocarpha micrantha is a caespitose annual sedge, 2-20 cm tall with narrow (0.5 mm) leaves up to 10 cm long. The 1 to 3 subsessile flower spikes are borne at the top of the stem. The spikes are ovoid, 2–6 mm long, with numerous perfect flowers concealed behind spirally imbricate scales. The inflorescence is subtended by 2 to 3 leaf-like bracts, the lowest of which looks like a continuation of the stem (Figure 1: Hitchcock et al. 1969; Gleason and Cronquist 1991; Douglas and Ceska 2001; Tucker 2002).

The densely tufted plants resemble the seedlings of many other sedge species that occur in the same habitat. In Canada *Lipocarpha micrantha* is perhaps most similar in aspect to Awned Cyperus (*Cyperus squarrosus* L.), another small annual sedge. *Lipocarpha micrantha* is distinguished from this and all other *Cyperus* species by its spirally arranged flowers.

Biology

Lipocarpha micrantha is only visible during a short period each year. It germinates in late summer, when dropping water levels expose the open sandy habitat it requires. Flowering and fruiting occur in August and September. High water levels may prevent germination from occurring, with the population remaining dormant until appropriate conditions occur. We do not know how long dormant seeds may remain viable, but field observations suggest they can persist at least two years. Migrating waterfowl may be a vector for long-distance dispersal.

Distribution

Lipocarpha micrantha ranges from Brazil to Canada. North of Mexico, the main range extends from Texas, north to northwestern Ontario, and east to the east coast of the United States. Disjunct populations have been recorded east and west of the main range, in Alabama, Arizona, British Columbia, California, Florida, Kentucky, Maine, New Mexico, New York, North Carolina, and Quebec (Tucker 2002).

In Canada, *Lipocarpha micrantha* occurs at Osoyoos Lake and Okanagan Lake in British Columbia (Figure 2), and at Rainy Lake and Lake of the Woods in northwestern Ontario (Figure 3). Populations along the Detroit River in southern Ontario and along the north shore of Lake Champlain in Quebec have been extirpated.

Habitat

Lipocarpha micrantha grows on sandy beaches and interdunal swales that are subject to seasonal flooding, but are protected from high waves or strong currents. It is usually found in areas of very sparse vegetation, and apparently is intolerant of competition from other plant species. These habitat conditions are maintained by fluctuating water levels. While *Lipocarpha micrantha*

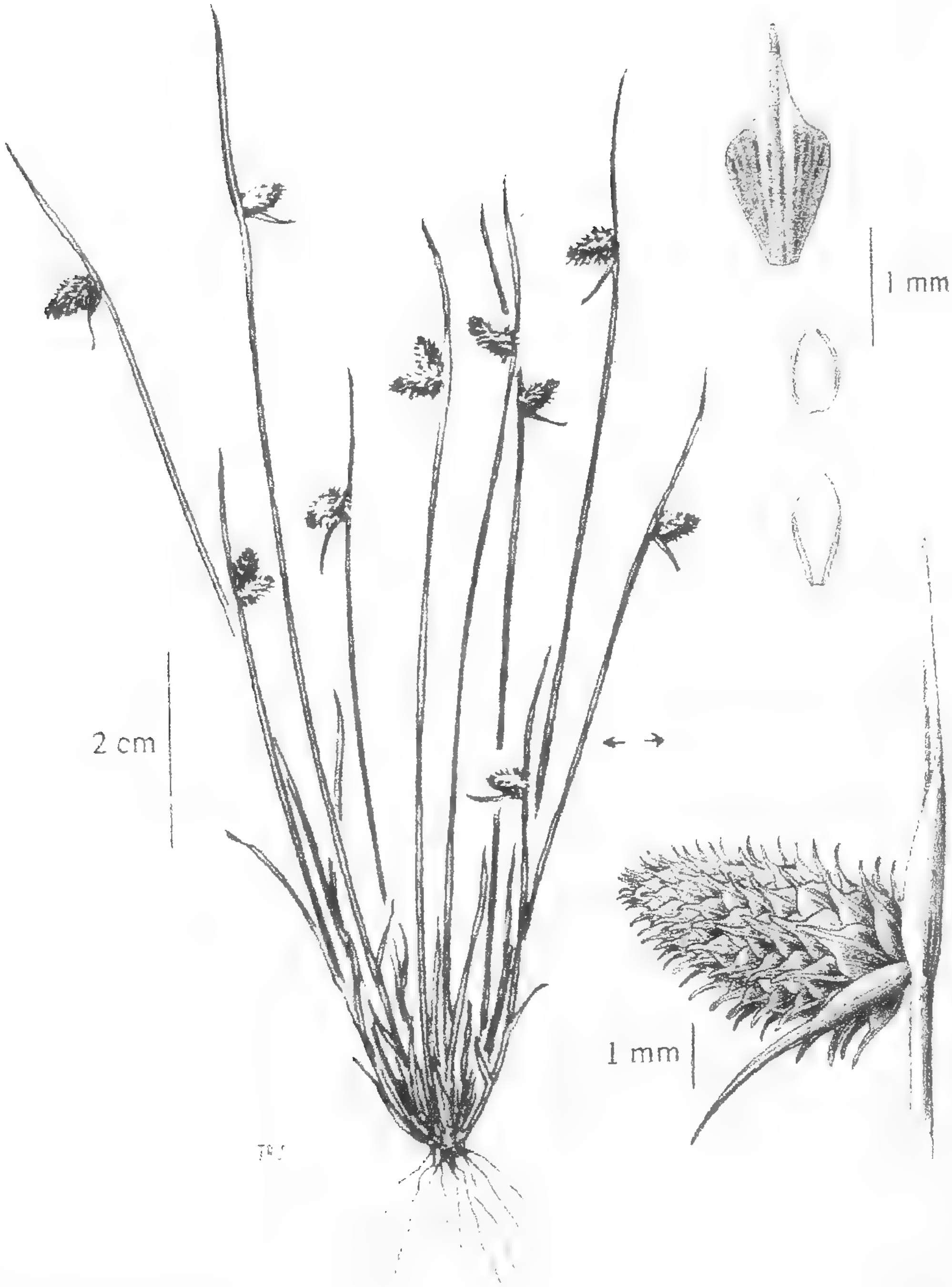

FIGURE 1. Illustration of *Lipocarpha micrantha* (Line drawing by permission from Hitchcock et al. 1969).

requires seasonal low water levels to germinate and flower, periodic high water is required to prevent more vigorous species from dominating its shoreline habitat (see Keddy and Reznicek 1986 for a discussion of the relationship between water level fluctuations and wetland vegetation).

Common associates of *Lipocarpha micrantha* include a variety of *Cyperus, Bidens,* and *Salix* species. *Cyperus squarrosus* has been noted as an associate at every station in Canada.

Population Trends and Limiting Factors

Of eight documented populations (Ceska and Ceska 1980; Oldham and Crins 1988; Sabourin et al. 1992*; Oldham 1996; Harris et al. 2000*; Oldham 2000; Smith et al. 2002*) of *Lipocarpha micrantha* in Canada, only four persist (Table 1).

The Lake Champlain population, in Missisquoi Bay, Quebec, was discovered in 1953 (Louis-Alphonse 3458, specimen at MT; herbarium acronyms follow Holmgren et al. 2003*), and was documented throughout the 1950s. However, a search in 1989 failed to find any plants (Sabourin et al. 1992*). Most recently, TWS searched the site in 2002 but did not find any plants despite the presence of appropriate habitat and moderate water levels. This site is adjacent to a campground and recreational activity may have contributed to the demise of this population. Water quality may also have been a factor, as a river flowing into Lake Champlain at this location smells strongly of raw sewage.

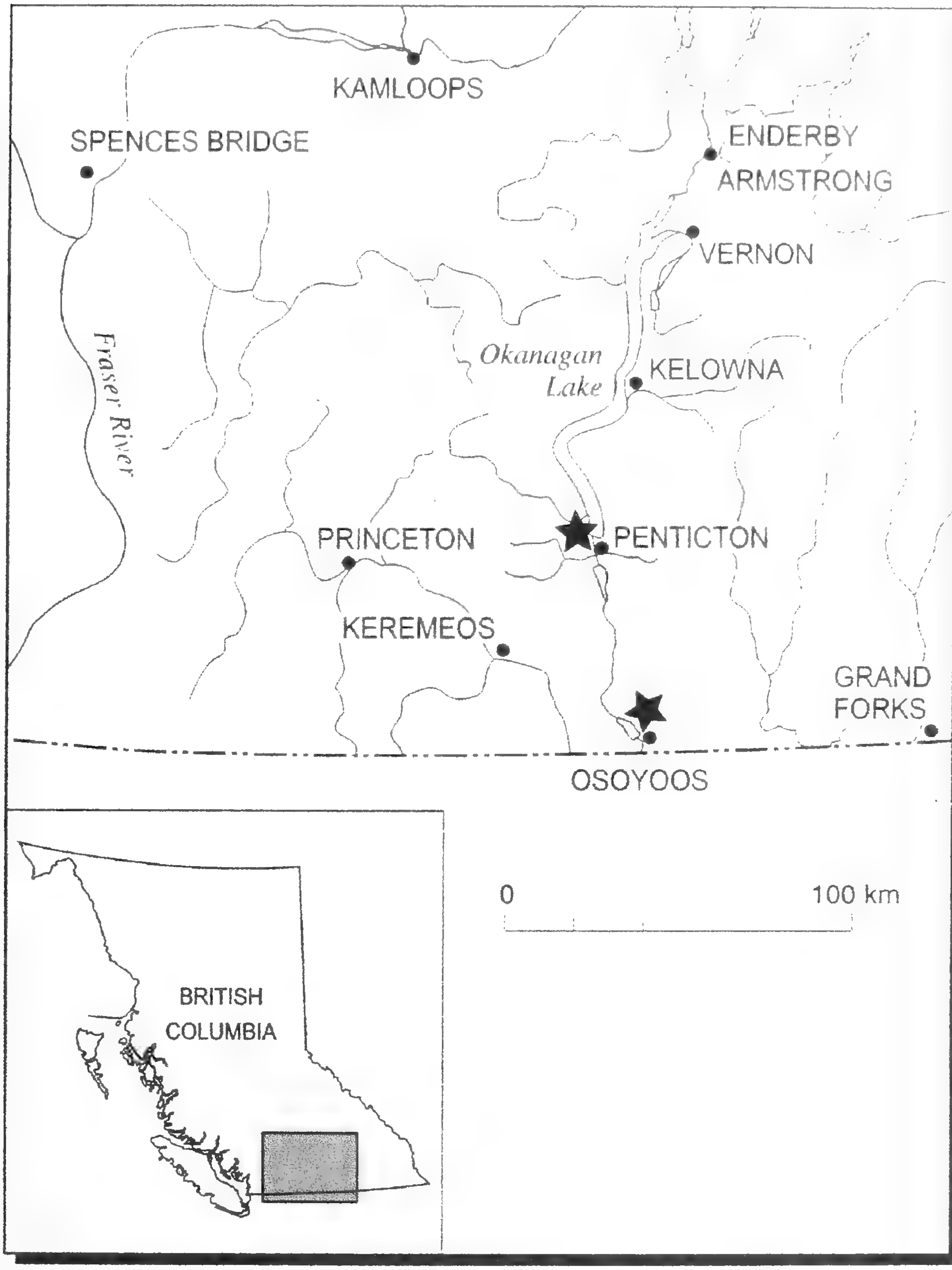

FIGURE 2. Distribution (stars) of *Lipocarpha micrantha* in British Columbia.

The oldest records of *Lipocarpha micrantha* in Canada are collections from the Detroit River shoreline, south of Windsor, Ontario, in 1892 (Macoun 28668, specimen at CAN) and 1901 (Macoun 7594, specimens at TRTE, GH). The populations represented by these collections have presumably been destroyed by shoreline development. The only recent records from this region are from the vicinity of Holiday Beach Conservation Area, near Amherstburg. This population was discovered in 1984, when 15 plants were observed (Oldham and Crins 1988). The population was still present in 1987 (Sabourin et al 1992*), but no plants were found during two searches by TWS in 2001. The habitat at Holiday Beach has been seriously degraded: dense mats of algae covered the beach, except in areas where it had been cleared away by heavy machinery.

TABLE 1. Locations and Population Sizes for *Lipocarpha micrantha* in Canada.

Site	Last Observation	Observer (Last Searcher)	Population (number/area)
Osoyoos Lake (British Columbia)	1980	Ceska	Extirpated
Osoyoos Lake, Osoyoos Indian Reserve (British Columbia)	2001	Douglas	30 000-50 000/2.3ha
Okanagan Lake, Sun Oka Beach Provincial Park (British Columbia)	2002	Klinkenberg	120/2 m^2
Sable Island (Ontario)	2001	Harris	1 800/0.4ha
Poundnet Bay (Ontario)	2000 (see text)	Harris	75/0.00lha
Holiday Beach (Ontario)	1987 (2001)	Oldham (Smith)	Extirpated
Detroit River (Ontario)	1901	Macoun	Extirpated
Missisquoi Bay (Quebec)	1957 (2002)	Louis-Alphonse (Smith)	Extirpated

The Lake of the Woods population, at Sable Island, Ontario, was discovered in 1995, and several thousand plants were noted at that time (Oldham, personal communication 2001). Surveys in 2001 documented approximately 1800 plants. The long sandspit island provides large areas of suitable habitat in Sable Island Provincial Nature Reserve.

As a consequence of the ephemeral nature of its habitat and its ability to remain dormant in unfavourable years, *Lipocarpha micrantha* may persist undetected at locations searched thoroughly by botanists. An unsuccessful search during highwater, when much potential habitat is temporarily unavailable, is therefore not justification for declaring a population extirpated. This was the case at Poundnet Bay on Rainy Lake, Ontario, in 2001, where water levels were well above average. No *Lipocarpha micrantha* plants were found there during 2001 A population of 75 plants was discovered at this location in 2000. When water levels return to average or below this area will provide habitat for *Lipocarpha micrantha.* It is known from several beaches on the Minnesota side of Rainy Lake.

Lipocarpha micrantha was first documented on Osoyoos Lake, British Columbia, by Ceska and Ceska (1980). Of the two populations noted, one has been eradicated by shoreline development. The British Columbia Conservation Data Centre has been monitoring the second population since 1991. In 2001 a total of between 30 000 and 50 000 plants were inventoried. This is the highest recorded population at that site, and it is the largest population in Canada. The high number is attributed to excellent growing conditions, and also to the higher search intensity in 2001. If conditions remain stable at this site the population should continue to thrive. However, local development plans at the site, including a casino and marina, would likely destroy about 50 to 60% of the remaining habitat. A third, small (20 plants over 2 m^2) population was discovered on the shoreline of Okanogan Lake in 2002.

Special Significance of the Species

Lipocarpha micrantha has very specific habitat requirements: open, sandy shorelines, protected from strong waves, with limited competition from other plants. It is extremely sensitive to alteration of both water levels and shoreline structure. As such it may be an important indicator of wetland quality.

Protection

Lipocarpha micrantha has a NatureServe (2002*) global rank of G5 or "secure". In the United States, *Lipocarpha micrantha* is listed as Endangered in Connecticut, Maryland, New Jersey, New York, and Pennsylvania, and it is listed as Threatened in Maine and Ohio (United States Department of Agriculture, Natural Resources Conservation Service 2002*). In Canada, *Lipocarpha micrantha is* ranked as N1 or "critically imperilled", and is listed as Threatened in Ontario (NHIC, 2003*) and Endangered/Threatened in British Columbia (Douglas et al. 2002).

Both extant Ontario populations of *Lipocarpha micrantha* are in a Provincial Nature Reserve and a Provincial Conservation Reserve. As such they are protected from shoreline development, but are subject to water level regulation. The extant populations in British Columbia occur on an Indian Reserve (Osoyoos Lake Indian Reserve #1) and in a Provincial Park (Sun Oka Beach Provincial Park). There is currently no specific provincial rare species legislation in place for the protection of endangered/threatened vascular plants in British Columbia. At the federal level the Species at Risk Act protects COSEWIC-listed plants on federal lands (which includes Indian Reserves). It also empowers the federal government to protect habitat outside federal lands if the province fails to protect listed species or their habitat; these mechanisms are discretionary.

Evaluation of Status

The status of *Lipocarpha micrantha* in Canada is precarious. The largest, apparently stable, population at Osoyoos Lake in British Columbia is threatened by planned development. Should this development proceed, approximately half of the remaining *Lipocarpha micrantha* plants in Canada will be physically destroyed, and the remaining habitat may no longer support the species. The two remaining Ontario populations are

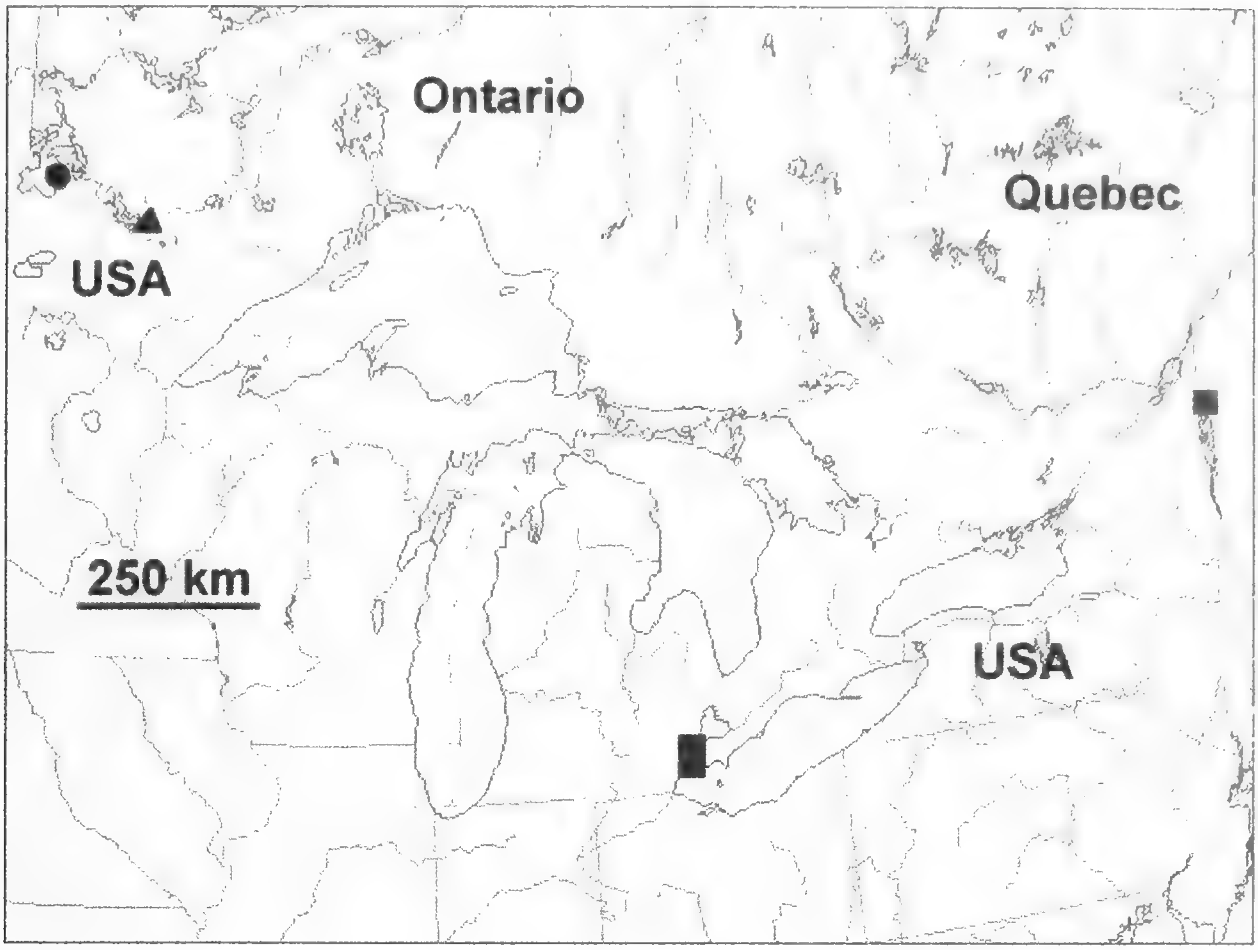

FIGURE 3. Distribution of *Lipocarpha micrantha* in Ontario and Quebec. Sable Island is shown as a circle, Poundnet Bay as a triangle. Squares denote extirpated populations.

relatively small, both in number and area, and therefore are vulnerable to environmental disturbance. If development at any of the remaining populations proceeds without consideration for this species it will very likely be extirpated from Canada. In particular, alteration of natural water level cycles could result in the destruction of the habitat required by *Lipocarpha micrantha.* The authors' recommendation that *Lipocarpha micrantha* be uplisted to Endangered was accepted by COSEWIC in November 2002.

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Immobilization of Clover-trapped White-tailed Deer, *Odocoileus virginianus*, with Medetomidine and Ketamine, and Antagonism with Atipamezole

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We evaluated the effectiveness of immobilizing Clover-trapped White-tailed Deer (*Odocoileus virginanus*) with medetomidine hydrochloride (HCl) and ketamine HCl during winter and summer by monitoring immobilization intervals and vital signs. In winter, we captured deer in Clover traps in 1 4-ha research enclosure for relocation to another on-site enclosure ($n = 5$). In summer, we captured free-ranging deer in Clover traps to attach radio-collars ($n = 4$). We administered an estimated 0.055 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl to adult (> 1.5 years of age) deer and 0.06 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl to subadult (< 1.5 years of age) deer. We used an intramuscular injection of atipamezole HCl as the antagonist at a rate of 0.275 mg/kg for adults and 0.3 mg/kg for subadults > 30 minutes post-induction. Mean induction time in winter was 11.2 minutes (SE = 2.5, range = 5.4 – 24.2) and 6.5 minutes (SE = 0.8, range = 6.2 – 7.5) in summer. After atipamezole HCl injection, the mean time to walking was 17.1 minutes (SE = 3.5, range = 7.5 – 41.5 minutes) in winter and 11.3 minutes (SE = 3.8, range = 4.7 – 13.5) in summer. Rectal temperature was relatively constant throughout immobilization; however rectal temperatures of 5 deer ($n = 3$ in winter; $n = 2$ in summer) exceeded 40°C, a sign of hyperthermia. Respiration rate and pulse rate peaked at about 20 minutes post-medetomidine HCl and ketamine HCl injection, then generally declined thereafter. No mortalities were observed in our study. Medetomidine HCl and ketamine HCl doses for Clover-trapped White-tailed Deer provided satisfactory induction times, sufficient level of anesthesia for short-distance relocation or radio-collar attachment, and were effectively reversed with an IM injection of atipamezole HCl.

Key words: White-tailed Deer, *Odocoileus virginianus*, atipamezole, capture, chemical restraint, Clover trap, deer, ketamine, immobilization, medetomidine, Missouri.

White-tailed Deer (*Odocoileus virginianus*) have been chemically immobilized with Telazol® (1:1 tiletamine hydrochloride (HCl) and zolazepam HCl) and xylazine HCl (Schultz et al. 1992; Kilpatrick and Spohr 1999), ketamine HCl and xylazine HCl (Mech et al. 1985; Farley et al. 1986; Kreeger et al. 1986; Ballard et al. 1998; Kilpatrick and Spohr 1999), etorphine and xylazine HCl (Presnell et al. 1973; Presidente et al. 1973; Nielsen 1982), xylazine HCl alone (Gibson et al. 1982), phencyclidine HCl (Dean et al. 1973), and succinylcholine chloride (Wesson et al. 1974; Jacobsen et al. 1976). Kreeger (1996) recommended 4.4 mg/kg Telazol® and 2.2 mg/kg xylazine HCl to immobilize White-tailed Deer; 0.125 mg/kg yohimbine HCl was the recommended antagonist. Recently, Kilpatrick and Spohr (1999) used a 4.8:3.9 mg/kg dose of Telazol®: xylazine HCl to dart free-ranging White-tailed Deer. Alternative drugs recommended by Kreeger (1996) include ketamine HCl and xylazine HCl, etorphine, xylazine alone (for calm deer only), and a combination of medetomidine HCl and ketamine HCl.

Medetomidine HCl depresses the central nervous system and acts similarly to xylazine HCl (Jalanka and Roeken 1990), but with greater affinity to alpha$_2$-adrenoreceptors (Klein and Klide 1989; Jalanka and Roeken 1990; Kreeger 1996). Ketamine HCl, an anesthetic, is often combined with a tranquilizer or sedative to improve induction and recovery (Haigh 1982; Kreeger 1996). Medetomidine HCl and ketamine HCl alone or in combination with other drugs have been successfully used to immobilize a diversity of large ungulates including Reindeer (*Rangifer tarandus tarandus*) (Ryeng et al. 2001, 2002), Mule Deer (*Odocoileus hemionus*) (Caulkett et al. 2000), Mule Deer/White-tailed Deer hybrids (Caulkett et al. 2000), Sika Deer (*Cervus nippon*) (Tsuruga et al. 1999), gemsbok (*Oryx gazella*) (Grobler et al. 2001), Roan Antelope (*Hippotragus equinus*) (Citino et al. 2001), Blue Duiker (*Cephalophus monticola*) (Bailey et al. 1995), Moose (*Alces alces*) (Arnemo 1995), Tigers (*Panthera tigris*) (Miller et al. 2003), Impala (*Aepyceros melampus*) (Bush et al. 2004), European Mink (*Mustela lutreola*) Fournier-Chambrillon et al. 2003) and Red Deer (*Cervus elaphus*) (Arnemo et al. 1994).

Notable among the advantages listed in these and other studies is the ability to reverse medetomidine HCl

with an intramuscular (IM) injection of atipamezole HCl (Tsuruga et al. 1999; Haulena et al. 2000). Atipamezole HCl is an extremely efficient alpha$_2$-adrenergic antagonist compared with yohimbine HCl and tolazoline HCl (Kreeger 1996) and effectively reverses medetomidine HCl in many wildlife species (Tsuruga et al. 1999; Haulena et al. 2000; Grobler et al. 2001). If medetomidine HCl and ketamine HCl were as efficient and safe as other immobilizing agents (e.g., Telazol® and xylazine HCl) and if an IM injection of atipamezole HCl was a safe and effective antagonist, this combination could prove efficacious in field studies. Our objective was to determine the effectiveness and safety of immobilizing Clover-trapped White-tailed Deer with medetomidine HCl and ketamine HCl, and the feasibility of reversing this combination with an IM injection of atipamezole HCl, during winter and summer by monitoring immobilization intervals and vital signs. To our knowledge, an evaluation using medetomidine HCl and ketamine HCl to immobilize free-ranging White-tailed Deer and antagonism by atipamezole HCl has not been previously published.

Methods

Our review of the medetomidine HCl and ketamine HCl combination took place in winter and summer 2001. In summer and winter, we trapped White-tailed Deer in Clover traps (McCullough 1975). During winter we trapped deer at the Charles W. Green Conservation Area, located near Ashland, Missouri. Traps were baited with corn, set each evening, and checked at sunrise. All winter-trapped and immobilized deer (n = 5) were captured within a 4-ha research enclosure for relocation to another on-site 4-ha enclosure. These deer were not habituated to humans.

In summer, we trapped White-tailed Deer at the Thomas S. Baskett Wildlife Research and Education Area, located near Ashland, Missouri. Traps, baited with salt, alfalfa, and corn, were set each evening and checked at sunrise. We captured and immobilized summer-trapped deer (n = 4) for purposes of radio-collar attachment. These deer were free-ranging animals and not habituated to humans.

In winter and summer, we immobilized adult deer (> 1.5 years of age) (n = 2 in winter; n = 3 in summer) using an estimated 0.055 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl; 0.06 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl was administered to subadult deer (< 1.5 years of age) (n = 3 in winter; n = 1 in summer). Adult deer, estimated to be 60 kg, were given 3.3 mg of 1 mg/ml Domitor® (medetomidine HCl; Orion Corporation, Orion–Farmos, Espoo, Finland) and 150 mg of 100 mg/ml Ketaset® (ketamine HCl; Fort Dodge Laboratories, Inc., Fort Dodge, Iowa, USA). Subadult deer, estimated to be 30 kg, were given 1.8 mg of 1 mg/ml medetomidine HCl and 75 mg of 100 mg/ml ketamine HCl. We injected drugs IM into the biceps femoris with a hand syringe. Sex and age (adult or subadult) were recorded and during winter each deer was marked with a plastic cattle ear tag in one ear for later identification. In summer, deer were fitted with radio-transmitters.

Following sedation in winter and summer, we applied an ophthalmic ointment and blindfolded the deer. In winter, we relocated deer to a different on-site 4-ha enclosure. Two or three field assistants placed the sedated deer into the rear of a vehicle (range from 100 to 300 m away), which was driven to the release enclosure (< 1 km driving distance). Each deer was carried into the enclosure (< 30 m away), and placed in a sternal recumbent position.

We reversed the medetomidine HCl and ketamine HCl combination with an IM injection of Antisedan® (atipamezole HCl; Orion Corporation, Orion–Farmos, Espoo, Finland) into the biceps femoris with a hand syringe at a rate of 0.275 mg/kg (16.5 mg of 5 mg/ml atipamezole HCl) for adults and 0.3 mg/kg (9 mg of 5 mg/ml atipamezole HCl) for subadults. We visually monitored all deer until they departed the area.

During winter and summer, we attempted to monitor immobilization intervals and vital signs at 5-minute intervals. For all deer, we recorded time of medetomidine HCl and ketamine HCl injection, induction (time from injection to time animal was handled), atipamezole HCl administration, "head up" (time when the animal first lifted its head), "standing" (time when the animal first stood up), and "walking" (time when the animal successfully departed the area). We also recorded respiration rate (breaths/minute), rectal temperature (°C), and pulse rate (beats/minute) at 5-minute intervals beginning at the time of medetomidine HCl and ketamine HCl injection for respiration rate and beginning 10 minutes post-medetomidine HCl and ketamine HCl injection for temperature and heart rate.

Results

Nine deer (n = 5 in winter, including 2 female subadults, 1 male subadult, 1 female adult, and 1 male adult; n = 4 in summer, including 3 adult females and 1 female subadult) were immobilized using the drug combination described above and either relocated or equipped with a radio-collar. No mortality has been observed 10 months post-winter immobilization and 5 months post-summer immobilization.

Mean induction time was 11.2 minutes (SE = 2.5, range = 5.4 – 24.3) in winter and 6.5 minutes (SE = 0.8, range = 6.2 – 7.5) in summer. Time to atipamezole HCl injection averaged 54.4 minutes (SE = 3.7, range = 37.7 – 79.2) in winter and 33.4 (SE = 1.3, range = 30.4 – 33.8) in summer. After atipamezole HCl injection, the mean time to head up was 11.4 minutes (SE = 2.9, range = 4 – 27.5) in winter and 9.3 minutes (SE = 0.7, range = 8.4 – 9.9) in summer. Mean time to standing was 15.9 minutes (SE = 3.6, range = 4.4 – 41) in winter and 10.5 minutes (SE = 3.2, range = 4.7 – 12.3) in summer. The mean time to walking was 17.1 minutes

(SE = 3.5, range = 7.5 – 41.5 minutes) in winter and 11.3 minutes (SE = 3.8, range = 4.7 – 13.5) in summer.

With the exception of rectal temperatures, other vital signs were considered normal (Table 1). Rectal temperatures were stable from 10 – 30 minutes post-medetomidine HCl and ketamine HCl injection in summer and winter (Table 1). Temperatures of 1 subadult female captured in winter were 37.4°C and 36.2°C at 70 and 110 minutes post-induction, respectively; thus, she was within 1.2°C of becoming hypothermic (defined as < 35°C; Kreeger 1996; DelGuidice et al. 2001). No attempt was made to increase body temperature of this individual prior to antagonism with atipamezole HCl. After atipamezole HCl administration, it took that individual 41.5 minutes to depart, the maximum time observed in our study. Rectal temperatures of 5 deer (n = 3 in winter, n = 2 in summer) exceeded 40°C, a sign of hyperthermia. No attempt was made to decrease body temperature of these animals prior to antagonism. Respiration rates showed little variability in summer and winter and were generally in the upper 20's to low 30's (breaths/minute) (Table 1) peaking at about 20 minutes post-medetomidine HCl and ketamine HCl injection. Pulse rates peaked about 20 minutes post-medetomidine HCl and ketamine HCl injection at 95 beats/minute (SE = 3.6) in winter and 103 beats/minute (SE = 1.4) in summer and declined thereafter to 74 beats/minute (SE = 5.6) in winter and 88 beats/minute (SE = 3.1) in summer at 30 minutes post-medetomidine HCl and ketamine HCl injection (Table 1). No other adverse side effects were noted.

During summer captures, response to IM injection of atipamezole HCl was predictable, as previously described by Jalanka and Roeken (1990). Within 3 – 6 minutes of atipamezole HCl injection, "ear-twitching" occurred, followed by leg extensions after an additional 3 – 6 minutes, and "head up" 2 minutes thereafter. Standing followed within another 2 minutes and the animal departed almost immediately with good muscle coordination.

Discussion

Medetomidine HCl and ketamine HCl doses for Clover-trapped deer provided satisfactory induction times, produced a sufficient level of anesthesia for short-distance relocation or radio-collar attachment, and were effectively reversed with an IM injection of atipamezole HCl. Small dosage volume, ease of preparation and predictable responses to sedation and to the antagonist make this combination a useful alternative to drug combinations that may require prolonged recovery.

Medetomidine HCl and ketamine HCl provided induction times similar to those reported in other studies and with other drugs. For 13 captive White-tailed Deer in Minnesota, it took 2 to 35 minutes (median = 8, SE = 1.2) from the time of xylazine HCl and ketamine HCl administration before deer lost the ability to stand (Mech et al. 1985). Our mean induction time in winter ($\bar{x}$ = 11.2 minutes, SE = 2.5, range = 5.4 – 24.3, n = 5) was about double the median time of 6.2 minutes (range = 0.5 – 17.3) reported by Jalanka and Roeken (1990) for 28 captive White-tailed Deer housed at the Helsinki Zoo, but similar to our summer mean time of 6.5 minutes (SE = 0.8, range = 6.2 – 7.5). In the Helsinki Zoo study, deer were given an average of 61 ug/kg (SD = 14, median = 58, range = 37 – 98) medetomidine HCl and a mean ketamine HCl dose of 1.6 mg/kg (SE = 0.3, median = 1.5, range = 1 – 2.3).

The time to walking after the IM injection of atipamezole HCl was similar to that for deer in other studies reversed with yohimbine HCl, but was less

TABLE 1. Mean ± SE (N) vital signs of White-tailed Deer immobilized with medetomidine hydrochloride (HCl) and ketamine HCl, and antagonized with atipamezole HCl during winter and summer 2001 in mid-Missouri for purposes of relocation (winter) and radio-collar attachment (summer). Adults were immobilized with 0.055 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl and subadults were immobilized with 0.06 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl. Adults were antagonized with 0.275 mg/kg of atipamezole HCl and subadults were antagonized with 0.03 mg/kg of atipamezole HCl. We have not reported data where information was collected on < 2 deer. Time 0 is the time of medetomidine HCl and ketamine HCl injection.

	Winter			Summer		
Time (minutes)	Respiration Rate (breaths/minute)	Pulse Rate (beats/minute)	Temperature (°C)	Respiration Rate (breaths/minute)	Pulse Rate (beats/minute)	Temperature (°C)
0	27.2 ± 2.1 (5)	–	–	23 ± 1.4 (4)	–	–
5	27.2 ± 2.3 (5)	–	–	23 ± 2.2 (4)	–	–
10	28.8 ± 2.9 (5)	87 ± 3.6 (4)	41.1 ± 0.5 (2)	31 ± 2.4 (4)	98 ± 2.0 (4)	39.9 ± 1.2 (4)
15	29.6 ± 3.2 (5)	88 ± 4.3 (4)	40.9 ± 0.8 (4)	31 ± 2.2 (4)	101 ± 1.9 (4)	39.8 ± 1.4 (4)
20	31 ± 3.2 (4)	94.7 ± 3.6 (3)	40.6 ± 1.2 (3)	30 ± 2.6 (4)	103 ± 1.9 (4)	39.8 ± 1.4 (4)
25	28 ± 3.1 (5)	86 ± 3.5 (4)	40.4 ± 1.2 (4)	30 ± 3.1 (4)	101 ± 2.4 (4)	39.6 ± 1.3 (4)
30	29.3 ± 3.6 (4)	74 ± 5.6 (2)	39.3 ± 1.9 (2)	32 ± 2.9 (4)	88 ± 3.1 (4)	39.3 ± 1.2 (4)
35	24 ± 2.4 (2)	75 ± 1.2 (2)	–	24 ± 0.0 (2)	–	–
40	–	–	–	24 ± 0.0 (2)	–	–
45	32 ± 3.3 (3)	–	–	–	–	–
50	28 ± 3.3 (3)	–	40.1 ± 1.2 (2)	–	–	–

variable. An intravenous injection of yohimbine HCl following xylazine HCl and ketamine HCl immobilization resulted in an adult male walking in 1.5 minutes (SE = 0.5, n = 2 immobilizations) to 26.5 minutes (SE = 11.5, n = 4 immobilizations) for an adult female (Mech et al. 1985). For 22 White-tailed Deer (18 free-ranging captured using drop nets and 4 captive) immobilized with xylazine HCl and ketamine HCl, an IM injection of yohimbine HCl produced a mean recovery time of 11.6 minutes (SE = 2.3) (Wallingford et al. 1996). Hsu and Shulaw (1984) used an IV injection of yohimbine HCl and reported a mean recovery time of 4.4 minutes (SD = 5.4 minutes) for xylazine HCl-immobilized deer.

With the exception of rectal temperature, the vital signs observed in this study were within the normal range of reported values for White-tailed Deer. Mautz and Fair (1980) reported pulse rates of a 46-kg adult White-tailed Deer female in July that was lying, standing/walking, and running at 65, 74, and 106 beats per minute, respectively. Pulse rates observed in this study were similar to predicted walking pulse rates of White-tailed Deer (Moen 1978: 722), yet higher than those rates reported by Jalanka and Roeken (1990: 267). Rectal temperatures of five deer were above 40°C, a sign of hyperthermia (Kreeger 1996). Average rectal temperatures in our study in winter (39.3°C at 30 minutes, SE = 1.9, n = 2) and summer (39.3°C at 30 minutes, SE = 1.2, n = 4) are similar to the maximum rectal temperatures reported by DelGuidice et al. (2001:1151) for White-tailed Deer captured by Clover trap and immobilized with xylazine HCl and ketamine HCl during the winter in Minnesota. Also in Minnesota, Rogers et al. (1987) reported rectal temperatures of two female free-ranging White-tailed Deer fawns in all seasons during various activities ranged between 38.2° and 40.1°C. Rectal temperatures of 3 adult male White-tailed Deer in Mississippi, averaged 39.3°C during late August and September and 38.6°C in early December (Demarais et al. 1986). As suggested by DelGiudice et al. (2001), corrective actions (i.e., packing snow around the animal) should be taken when immobilized animals become hyperthermic. Consequently, rectal temperatures should be monitored and protocols should be established to determine when corrective actions should begin (DelGiudice et al. 2001).

Both medetomidine HCl and ketamine HCl have wide safety margins, produce calm inductions in several artiodactyls, are safe for humans (Jalanka and Roeken 1990), and have not caused any apparent detrimental effects in pregnant females (Jalanka 1993). Few adverse side effects were noted by Jalanka and Roeken (1990) after 1240 immobilizations with medetomidine HCl, ketamine HCl, and antagonism with atipamezole HCl. Worth noting, some ruminants became resedated between 30 and 240 minutes post-IV reversal with atipamezole HCl (Jalanka and Roeken 1990) and unremarkable ruminal tympany was common in ruminants prior to atipamezole HCl administration (Jalanka and Roeken 1990; Jalanka 1993).

A disadvantage of the medetomidine HCl, ketamine HCl, and atipamezole HCl combination is cost. In U.S. currency, cost to immobilize each adult deer was \$34.72 (\$32.76 for medetomidine HCl and \$1.96 for ketamine HCl) and \$18.85 for each subadult deer (\$17.87 for medetomidine HCl and \$0.98 for ketamine HCl). Atipamezole HCl cost \$33.22 per adult deer and \$18.14 for each subadult deer. In contrast, Kilpatrick and Spohr (1999) reported a cost of \$8.44/deer for Telazol® and xylazine HCl immoblized deer and \$6.34/deer for ketamine HCl and xylazine HCl without lyophilizing costs. With lyophilizing, costs were \$10.05/deer for Telazol® and xylazine HCl and \$16.49 for ketamine HCl and xylazine HCl (Kilpatrick and Spohr 1999). Consequently, use of medetomidine HCl, ketamine HCl, and atipamezole HCl may be cost-prohibitive in studies requiring immobilization of many animals. However, given the desirable properties discussed above, including rapid reversal that requires less manpower time, these desirable qualities may outweigh drug costs. Also, the ability to administer an antagonist IM may be advantageous in field studies (Wallingford et al. 1996). We recommend researchers investigate the utility of reversing the less costly and popular Telazol®/xylazine HCl and ketamine HCl/xylazine HCl combinations with an IM injection of atipamezole HCl.

The combination of medetomidine HCl, ketamine HCl, and atipamezole HCl reported herein provided an effective level of anesthesia for Clover-trapped White-tailed Deer. We recommend the use of 0.055 mg/kg medetomidine and 2.5 mg/kg ketamine HCl to immobilize adult Clover-trapped White-tailed Deer and 0.06 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl for subadults. Furthermore, we recommend 0.275 mg/kg and 0.3 mg/kg of atipamezole, injected IM, to reverse this combination in adults and subadults, respectively.

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Predation on Two Mule Deer, *Odocoileus hemionus*, by a Canada Lynx, *Lynx canadensis*, in the Southern Canadian Rocky Mountains

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A male Canada Lynx (*Lynx canadensis*) killed two Mule Deer (*Odocoileus hemionus*) in the southern Canadian Rocky Mountains in January 1999 and made use of the kills for 28 days. Canada Lynx predation on ungulates has been reported but is rare, and accounts have been brief. We detail the lynx behaviour associated with the kills and their consumption. An infrared monitor and attached camera were used to register daily activity at the kill site. We speculate on the factors that may have influenced this opportunistic predation event.

Key Words: Canada Lynx, *Lynx canadensis*, infrared monitor, Mule Deer, *Odocoileus hemionus*, predation, British Columbia.

The Canada Lynx (*Lynx canadensis*), hereafter referred to as lynx, preys mainly on Snowshoe Hares (*Lepus americanus*) and other small mammals, but rare accounts of ungulate predation have been noted (e.g., Saunders 1963; van Zyll de Jong 1966; Parker et al. 1983; Stephenson et al. 1991). However, these accounts do not describe lynx behaviour associated with the kills or their consumption. We give a detailed description of two Mule Deer (*Odocoileus hemionus*) kills made by a lynx and its subsequent use of them for 28 days. The observations were made in the course of an in-depth field study of lynx ecology in the southern Canadian Rocky Mountains of southeastern British Columbia and southwestern Alberta.

While snow-tracking on 18 January 1999, we found two Mule Deer that had been killed by a radio-collared adult male Canada Lynx in Kootenay National Park, British Columbia (51° N, 116° W). One was a doe aged by cementum annuli to be 3.5 years, and we estimated the other deer to be a fawn (teeth not completely erupted). The kills were separated by a distance of 10 m and were located at 1580 m elevation on a 15° slope of northwest aspect in a closed-canopy forest of Lodgepole Pine (*Pinus contorta*), Engelmann Spruce (*Picea engelmannii*), and Subalpine Fir (*Abies lasiocarpa*). The understory was sparse, although the immediate area around the kill site had some woody debris to a depth of about 1 m and some conifer thickets. The snow depth at the site was 90 cm and lynx penetration was 9-14 cm.

The fawn apparently was killed on 14-15 January, judging from daily radio-telemetry fixes of the lynx and accumulated snow cover. The shoulders, rib cage, part of the neck, upper front legs and organs had been consumed. The front and rear had been severed and lay twisted and partially cached in a hollow in the snow. The doe was killed on 18 January between about 1300 and 1500 h. On initial inspection, no snow had accumulated on the carcass, and the blood had not yet coagulated or frozen. The deer was found lying on its side with legs extended, and no part had yet been consumed.

Teeth of both deer were in good condition, and no deformities of their legs or hooves were apparent. The doe appeared to be in good physical condition. Both deer had major wounds on the dorsal side of their necks, and the spacing of obvious tooth-punctures matched that of a lynx (Figure 1). The cause of death of the fawn could not be determined because it had been consumed to a great extent and was not intact. On the doe, several puncture wounds were located in two small areas on the dorsal to slightly lateral area of the neck, 10-15 cm behind the ears. Claw marks on the deer's back and shoulders suggested that the lynx had leapt onto the deer and had been "riding" while biting it.

Evidence of predation of the fawn was obscured by recent snow, but old blood stains 2 m from the carcass suggested that it had been killed and not scavenged. When removing the mandible of the fawn, we found pieces of undigested Subalpine Fir in its mouth, suggesting that the animal had been browsing shortly before it died.

Tracks in the snow provided a clear record of how the lynx encountered and stalked the doe. The lynx approached this deer from a slightly higher elevation than where both kills were found, partially circling the site for about 100 m. It briefly stopped at the edge of a small opening about 50 m from the kill site, and then again 25 m uphill on a knoll. Moving downhill in a normal gait, the lynx used several fallen logs for cover, but was clearly stalking for the last 10 m. It then made three bounds before its attack, as the doe stood next to a thicket of mixed-age trees. The deer appeared to succumb ≤4 m from the attack site. The lynx then dragged the carcass about 7 m to its final location.

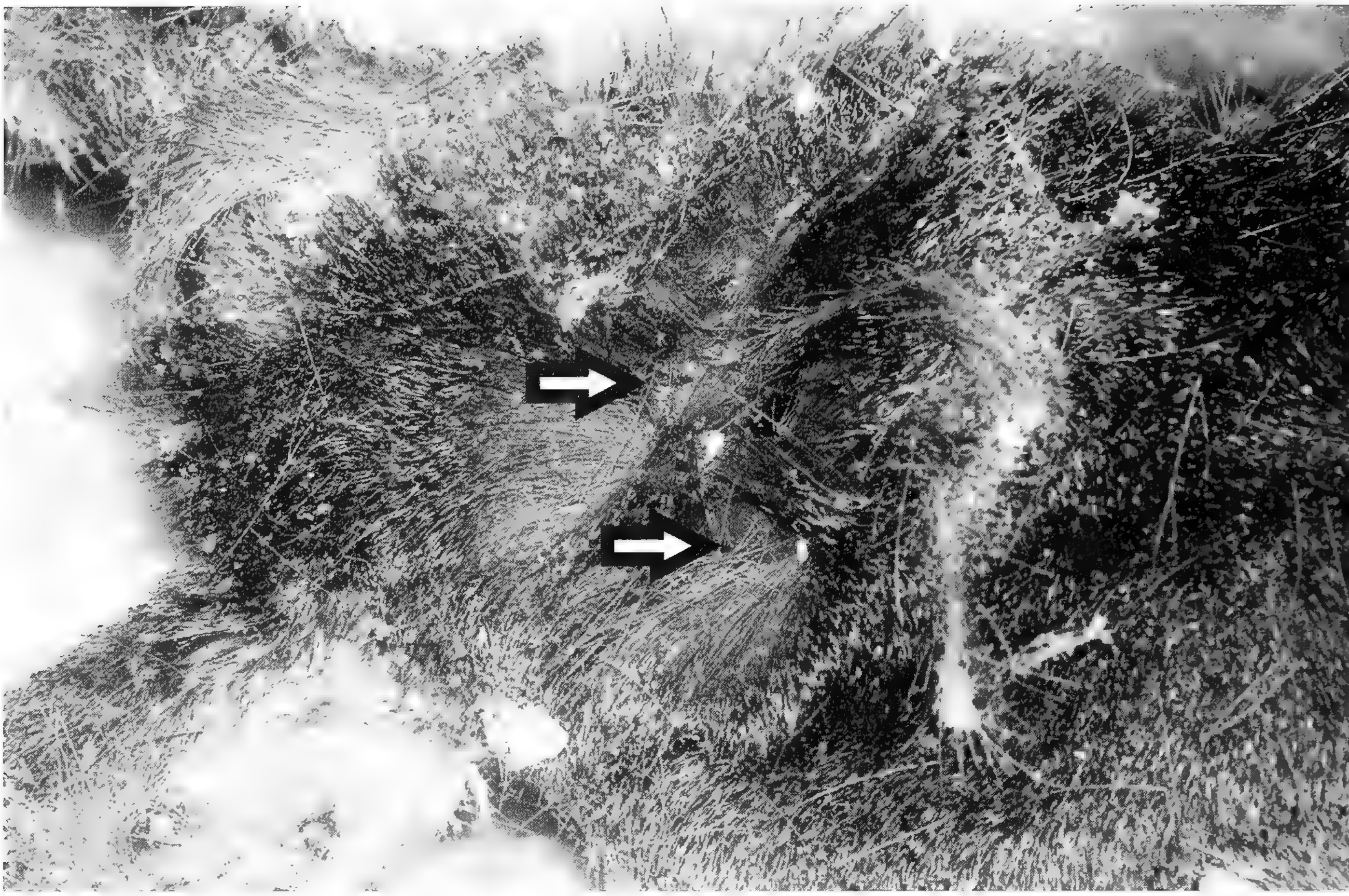

FIGURE 1. Neck wound (arrows indicate puncture locations) resulting in the death of an adult female Mule Deer by a Canada Lynx in the southern Canadian Rocky Mountains, January 1999.

Six site visits conducted over the three weeks following the initial find indicated that the lynx first fed on the doe's neck, continued to feed on the shoulders and rib cage, and finally ate the rear and internal organs. Deer hair had been removed and was positioned around and on top of the kill. There were several well-used lynx beds that appeared to be strategically located upslope, <120 m from the kill site, with clear downhill views. The hindquarters of the fawn were moved to 4 different locations between our site visits, and each time were cached under snow and branches. It is possible that this was prompted by our inspections.

On 29 January we installed an infrared monitor (Trailmaster™ 1500, Goodson and Associates Inc., Kansas, with attached Olympus camera) at the doe's kill site to document the 24-hour activity of the lynx at the site. The monitor was programmed to register all beam interferences, while the remote camera was set to take a photo upon beam interference, with ≤1 photo/15 min and between 0900 h and 1630 h to avoid flash disturbance. Because the lynx no longer appeared to be feeding on the fawn, we expected that all subsequent feeding events would be registered.

Twenty photos of the lynx were obtained and showed that only this animal fed on the carcass (e.g., Figure 2). In addition, no other predator was detected at the site during inspections that occurred about every four days. lynx activity at the kill peaked around midnight and in the late morning (Figure 3).

The lynx abandoned the kill site after 28 days, at which time the head and lower side of the doe's carcass were frozen into the ground. Scratch marks suggested that the lynx had unsuccessfully tried to remove some snow to access parts of the deer. Upon incidental recapture 16 days later, the lynx weighed 15.9 kg, 18.6% more than at his previous and original capture in November 1996, while skeletal measurements had not changed (C. D. Apps, unpublished data).

Our account is consistent with the observations by Stephenson et al. (1991) of lynx ambushing ungulate prey at close range. They reported a lynx remaining on a Caribou (*Rangifer tarandus*) kill for 42 days. In our study, the Lynx apparently abandoned the site because it could not make use of the carcass remains, and it might have stayed longer had conditions permitted.

Previous reports of lynx predation on ungulates have been associated with the low phase of the approximate 10-year population cycle of Snowshoe Hares, the lynx's primary prey. The reliance of lynx on alternate prey is greatest at this time (Mowat et al. 2000). Although the deer kills we report occurred during an assumed Snowshoe Hare population peak, hare densities in the study area were comparable to boreal regions during the cyclic low (Apps 2000; C.D. Apps, unpublished data).

FIGURE 2. Remote camera photo of a Canada Lynx at the carcass of a Mule Deer it killed in the southern Canadian Rocky Mountains, January 1999.

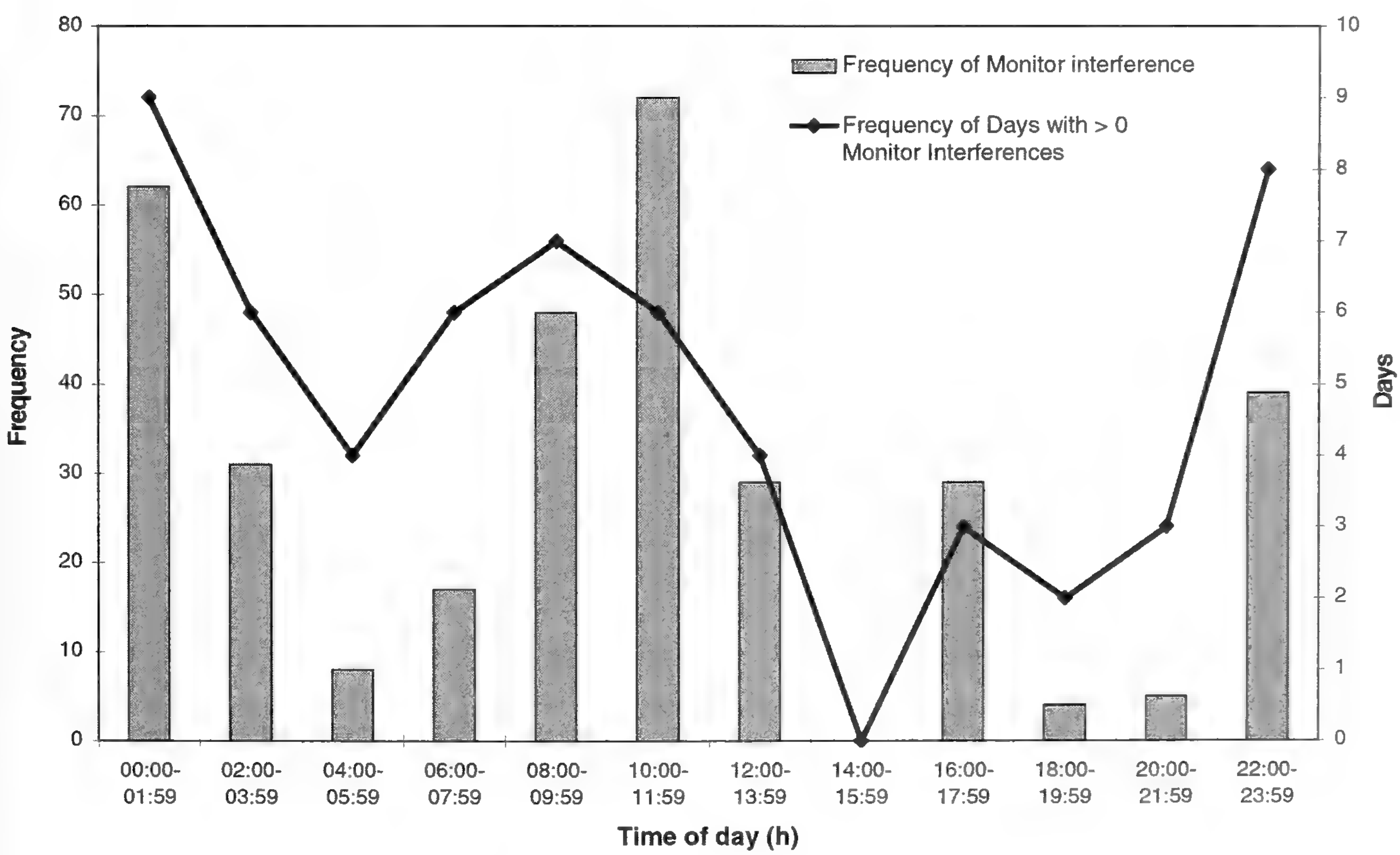

FIGURE 3. Lynx activity while feeding on a Mule Deer kill over 11 days in the southern Canadian Rocky Mountains, January 1999. Total frequency (1 min. intervals; $n = 344$) and number of days that the Canada Lynx triggered an infrared monitor (monitor interference) per 2-h period are shown.

We further note that the relatively high elevation and deep snow of the kill site made it an atypical location for Mule Deer during mid-winter. We speculate that the deer may have been avoiding other predators, most notably Gray Wolves (*Canis lupus*) that travel primarily through the valley bottom. Thus, we expect that this predation was opportunistic, perhaps influenced by relatively low densities of Snowshoe Hares, the age class and sex of the lynx (adult male), and the vulnerability of the deer.

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Effect of Fire Intensity and Depth of Burn on Lowbush Blueberry, *Vaccinium angustifolium*, and Velvet Leaf Blueberry, *Vaccinium myrtilloides*, Production in Eastern Ontario

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The effects of prescribed fire intensity and depth of burn were investigated on Lowbush Blueberry (*Vaccinium angustifolium*) and Velvet Leaf Blueberry (*Vaccinium myrtilloides*) stem density, blueberry production and the number of blueberries/stem in a clear-cut Jack Pine, *Pinus banksiana,* ecosystem of eastern Ontario. Blueberry production and stem density were significantly ($P < 0.001$) increased by low intensity prescribed fires of 597 and 1268 kW/m. In contrast, prescribed fires of medium and high intensities did not affect blueberry production and stem density. The number of blueberries/stem was not affected ($P = 0.056$) by prescribed burning, two years after treatment. Pearson's multiple correlation analysis showed that blueberry production (R: -0.683, $P < 0.01$), stem density (R: 0.733, $P < 0.01$) and the number of blueberries/stem (R: 0.803, $P < 0.01$) correlated with depth of burn. As well, blueberry production (R: 0.507, $P < 0.05$) and stem density (R: -0.504, $P < 0.05$) correlated with fire intensity. Depth of burn was a better predictor of berry production and stem density than fire intensity. These results suggest that only low intensity fires with little penetrating effect in the ground should be used to manage blueberry crops.

Key Words: Lowbush blueberry, *Vaccinium augustifolium, Vaccinium myrtilloides,* wildfire, nontimber forest products (NTFP).

Nontimber forest products (NTFP) are all botanical commodities harvested from the forest excluding industrial timber use (Duchesne et al. 2000). NTFP are critical to the economy of forest and rural communities by providing food as well as supplemental income, which often improves the standard of living of rural and First Nation communities (Brubaker 1997; Duchesne et al. 2001; Mohammed 1999). Despite the socio-economic importance of this industry there has been little scientific research conducted for its support, presumably because of its novelty. However, the long-term success of the NTFP industry depends on acquiring precise knowledge regarding the availability, and sustainability of wild harvests as well as strategies to domesticate and manage many of the most sought after NTFP species. Species such as Lowbush Blueberry (*Vaccinium angustifolium*) and Velvet Leaf Blueberry (*Vaccinium myrtilloides*) need to be further domesticated and/or managed in natural ecosystems to meet the growing demand from the food and nutraceutical industries (Duchesne et al. 2001). This paper describes research conducted to improve blueberry management.

Canada is the world's largest producer of wild blueberries (Lowbush and Velvet Leaf blueberries) with an annual output of $42 425 million in farm gate value resulting in production of 43 511 tonnes of frozen blueberries (Agriculture and Agri-Food Canada 2002). The demand for Lowbush and Velvet Leaf blueberries is such that management of natural or established sites is conducted to promote optimal yields ranging from 3360 to 8967 kg/ha (Mohammed 1999). Given that blueberries are worth approximately $1.00/kg to farmers, the annual output of managed fields ranges from $3360 to $8967/ha, which is far superior to the average timber growth of Canada's forests of 1.59 m^3/ha/year (Lowe et al. 1996) with an approximate value of $100/ha/year.

Pruning of blueberry fields, either by mowing or burning, is used routinely to maximize blueberry production (Badcock 1958; Eaton 1958; Eaton and White 1960) as it stimulates the development of new shoots from shallow rhizomes (Van Hoefs and Shay 1981). In turn, new shoots are preferred over old shoots as the ratio of flower buds to leaf buds is greater on new shoots than on older shoots (Hall et al. 1972). Fire pruning of blueberry fields is generally accomplished by using straw as a fire carrier or tractor mounted oil or propane gas burners that emit a constant flame (Blatt et al. 1989). Burning also has the added advantage of reducing problems with insects and disease (Blatt et al. 1989; Smith and Hilton 1971). Although fire is frequently used for the management of Lowbush and Velvet Leaf blueberries (Blatt et al. 1989), which form one commercial crop, there is a lack of information about the relationship between fire behaviour and its impact on berry production. Indeed, current prescriptions aim at using fires that kill all stems (Blatt et al. 1989). However, fire behaviour varies a great deal even during prescribed burns, which in turn affects the ecological outcome of post-fire ecosystems (McRae et al. 2001).

Frontal fire intensity (or Byram's fireline intensity) is a measurement of the quantity of energy liberated as a fireline moves through an ecosystem, and is the most encompassing physical measurement of fire behavior related to ecological impacts (reviewed by Alexander 1982 and McRae et al. 2001). Fire intensity is sometimes used together with depth of burn (Miller 1977), which is a measurement of heat penetration into the soil. However, both frontal fire intensity and depth of burn are relatively new concepts in fire ecology and have never been applied to blueberry management. Hence, the objective of this study was to investigate the effect of fires of different intensities and depth of burn on Lowbush and Velvet Leaf blueberry production and vegetative growth.

Materials and Methods

Study site

The study area is located at Frontier Lake (46°00'N, 77°33'W) in a Jack Pine, *Pinus banksiana,* stand in eastern Ontario within the middle Ottawa section (L.4c) of the Great Lakes – St. Lawrence Forest region (Rowe 1972). As reported by Herr et al. (1994), the site is near the Petawawa Research Forest, and is relatively flat, with a difference in elevation of approximately 4 m over 1.0 km. The surface deposit is a fine-grained and deep sand (10-30 m deep) (Gadd 1962) and the soil is a humo-ferric podzol. The study site was selected because of its uniformity in tree composition and topography. It was harvested in 1942 and 1943 leaving residual standing timber with a stump diameter of 17.5 cm or less. Dendrochronological analysis of dominant trees and snags with multiple fire scars suggests that the study site sustained several fires, with the most recent in 1943, presumably from broadcast slash burning following harvesting (E. Stechishen, personal communication).

Presently, the stand comprises a mix of Jack Pine (*Pinus banksiana*), Red Pine (*Pinus resinosa*) and White Pine (*Pinus strobus*) with the Red and White pine forming an emergent layer (Herr et al. 1994). Although the Jack and Red pine are of similar ages, the Jack Pine has higher relative density and is the dominant tree species on the site. Other plant species found at the site include serviceberry (*Amelanchier* sp.), Sweet Fern (*Comptonia peregrina*), Wintergreen (*Gaultheria procumbens*), Sheep Laurel (*Kalmia angustifolia*), Ground Pine (*Lycopodium complanatum*), Cow Parsnip (*Maianthemum canadense*), Hairy Solomon's Seal (*Polygonatum pubescens*), Bracken Fern (*Pteridium aquilinum*) and Sand Cherry (*Prunus pumila*).

Treatments

In the summer of 1990, an area of 150 m × 1000 m was clear-cut with the slash left in place. The site was divided into 40 plots of 35 m × 70 m with 8 m fireguards established around each plot. In 1991, ten plots were burned under different indices of the Canadian Forest Fire Weather Index (FWI) system (Table 1) resulting in frontal fire intensities that varied from 597 to 21 305 kW/m and depth of burn that varied from 0.37 to 2.78 cm (McAlpine 1995). This range of fire intensity and depth of burn far exceeds the range of fire behaviour currently used in blueberry management (unpublished observations).

Pre- and post-burn fuel loads were measured for both slash and duff fuels (McRae et al. 1979). Fire rate of spread was measured with a pin grid network on each plot; fire arrival times at each pin were recorded to provide distance and time information. Fuel consumption was determined as the difference between these two values. Fire intensity was calculated using Byram's (Byram 1959: *cited in* McAlpine 1995)

TABLE 1. Fire weather[1], fire behaviour parameters[1] and blueberry production from thirteen 35 m × 75 m plots in a clear cut Jack Pine after prescribed burning of different fire intensities at Frontier Lake Experimental site in Eastern Ontario.

Plot Number	Date of burn[1]	FWI [1]	Depth[1] of Burn (cm)	Intensity[1] (kW/m)	Blueberries[2] (g/m^2)	Stem density[2] ($stems/m^2$)	Blueberries/stem[2] (N/plant)
2	08/08/91	3.1	0.37	597	492.86 a (167.4)	73.2 a (8.5)	7.53 a (3.4)
7	08/08/91	3.6	0.38	1 268	242.18 a (79.44)	44.2 b (9.8)	5.52 a (1.6)
44	06/24/91	15.8	1.79	2 305	10.81 b (7.6)	5.9 c (0.7)	2.26 a (1.8)
40	07/10/91	4.3	2.78	4 844	11.14 b (5.9)	9.4 c (2.9)	0.90 a (0.69)
32	07/12/91	9.6	1.85	7 600	8.78 b (8.7)	6.7 c (5.6)	0.53 a (0.46)
26	06/14/91	11.0	3.50	10 941	4.96 b (4.8)	9.9 c (7.1)	3.40 a (2.9)
46	06/24/91	17.4	1.95	12 065	2.01 b (1.1)	4.0 c (1.9)	3.10 a (2.7)
36	07/12/91	3.9	2.71	13 202	27.20 b (8.9)	12.1 c (4.6)	2.59 a (1.13)
43	07/10/91	8.8	2.64	20 334	0.53 b (0.24)	5.7 c (4.1)	0.50 a (0.42)
24	06/14/91	21.0	1.79	21 305	5.33 b (0.48)	13.8 c (2.4)	0.04 a (0.06)
	Controls[3]	—	—	—	9.01 b (2.6)	5.9 c (1.48)	0.78 a (0.25)

[1] from McAlpine (1995).
[2] within column means followed by a different letter are significantly different at $P < 0.05$ determined by ANOVA. Observed significance level was adjusted with the Bonferroni procedure.
[3] controls consisted of three unburned plots adjacent to the burned over plots.

intensity equation I=HwR, where I is the intensity of the fire (kW/m), H is the fuel low heat of combustion (assumed to be 18 000 kJ/kg), w is the weight of fuel consumed in the active front (kg/m^2) (all fuel consumed was assumed to have been burned by the active fire front), and R is the rate of spread (m/sec).

To determine depth of burn, ten 50 cm steel pins mounted with horizontal markers were used in each plot to mark the top of the soil litter layer prior to each burn. Immediately after the burn, the distance between the horizontal marker and the top of the litter layer was measured with a ruler and called depth of burn.

Two years following prescribed burning, there were 45 plant species in our research plots. The most important species in terms the biomass and frequency (in decreasing order of importance) were *P. aquilinum*, *V. angustifolium*, *V. myrtilloides*, *Amelanchier* sp., *P. pumila*, *Comptonia peregrina*, *Kalmia angustifolia*, Yellow Panic-grass (*Panicum xanthophysum*), and Houton's Sedge (*Carex houghtonii)* (Tellier et al. 1995, 1996).

Blueberry collection

To compare the effect of fire intensity and depth of burn, blueberries were collected two years after prescribed fire from the ten burned over plots and from three control plots. Controls consisted of three clearcut 35 m × 70 m plots adjacent to the burned-over plots. Blueberries were not collected in subsequent years because of logistical reasons limiting access to the research plots.

For this study, three 3 m × 3 m quadrats were randomly established in each of the 35 m × 70 m plots. The perimeter of each of the 3 m × 3 m quadrats was delineated with a string tied 40 cm above ground and all berries within the 3 m × 3 m quadrats were picked, advancing from the edge of the plot inwards. Ripe, over-ripe, green, and deformed blueberries were included in the harvest. All plots were harvested on 13 July and 14 July 1993. The harvested berries were kept in plastic coolers in the shade until the end of the collection day and their fresh weight determined in the laboratory the same evening. The bags were then placed in drying ovens at 50°C for 5 days before weighing. Because the moisture content of blueberries (83.1 ± 0.8 %) was comparable among all plots (P = 0.22) and consistent with published data (Usui et al. 1994), the results were expressed in terms of fresh weight only. As well, no attempt was made to distinguish between *V. myrtilloides* and *V. angustifolium* as the frequency of these species (1:15- 1:30, *myrtilloides*: *angustifolium*) was not significantly different among treatments (P = 0.57).

To compare the effect of fire intensity and depth of burn on the vegetative abundance of *V. myrtilloides* and *V. angustifolium,* the number of stems of both species was determined two years after prescribed fire from the ten burned over plots and three control plots. Once the berries had been removed from the 3 m × 3 m quadrats, the number of stems was recorded for the entire quadrat and expressed as stems/m^2.

As well, the number of blueberries/stem was compared among the prescribed burns and the control. For this, 100 stems were selected randomly outside the 3 m × 3 m quadrats and the number of blueberries determined for each stem. This protocol was repeated in each of the ten prescribed burn plots as well as each of the three control plots.

Statistical analyses

Analysis of variance (ANOVA) was conducted to compare blueberry production, stem density and blueberry abundance/stem among the prescribed burns and the controls (Systat 1997). For statistical analyses the three control plots were pooled as one treatment whereas each of the ten burned over plots was treated as a separate treatment (McAlpine 1995). Means were compared using the Bonferroni procedure (Systat 1997). Pearson's multiple correlation analysis was conducted to determine the relationship between frontal fire intensity, depth of burn, berry production and the number of blueberries/stem (Systat 1997).

Results

Blueberry production (g/m^2) differed significantly ($P < 0.001$) among treatments. The greatest blueberry production was observed in prescribed fires of 597 and 1268 kW/m whereas there were no significant differences among blueberry production of the other treatments, including controls (Table 1). Likewise stem density/ha differed among treatments ($P < 0.001$) and was greatest in the fires of 597 and 1268 kW/m. There was no difference in the number of blueberries/plant among the other treatments including the controls ($P = 0.056$).

Pearson's multiple correlation analysis showed that fire intensity correlated ($P < 0.05$) with blueberry production, and stem density (Table 2). Depth of burn correlated ($P < 0.01$) with blueberry production, stem density and blueberries/plant. Depth of burn showed better correlations with blueberry production, number of blueberries/plant and stem density than fire intensity (Table 2).

Discussion

Several studies have demonstrated that the response of ecosystems varies greatly with frontal fire intensity and depth of burn. Fire intensity has been shown to correlate with *P. banksiana* regeneration (Weber et al. 1987) and post-fire abundance of *P. aquilinum* (Tellier et al. 1995). Low fire intensities stimulated *Corylus cornuta* sprouting and height growth of *Rubus ideaus* (Johnston and Woodard 1985). Biomass nutrient retention (Duchesne and Tellier 1997) and soil seed bank and competing vegetation dynamics along with *P. resinosa* and *P. strobus* seedling performance are also affected by prescribed burning intensity (Tellier et al. 1995, 1996; Whittle et al. 1997). Soil microbial activity and

TABLE 2. Pearson's multiple correlation analysis among fire intensity, depth of burn, blueberry biomass, number of blueberries/stem, and stem density.

	Intensity	Blueberries/ha	Depth of burn	Blueberries/stem	Stem density
Intensity	1.000				
Blueberries/ha	-0.507*	1.000			
Depth of burn	0.517*	-0.683**	1.000		
Blueberries/stem	-0.461	0.803**	-0.577**	1.000	
Stem density	-0.504*	0.766**	-0.724**	0.471	1.000

* significant at $P < 0.05$
** significant at $P < 0.01$

diversity were also affected by fire intensity (Duchesne and Wetzel 2000; Staddon et al. 1998a, 1998b).

Fire has been used for hundreds of years in blueberry management by Indigenous people (Chapeskie 2001) and by farmers (Badcock 1958; Blatt et al. 1989), mostly using spring fires. This investigation presents the first comprehensive data on the effect of fire intensity and depth of burn on natural blueberry production, which are indicated as critical factors to consider in blueberry management. Indeed, the current findings show that fire intensity must be kept low in order to increase blueberry productivity using prescribed fire. As well, care must also be given to reduce depth of burn, which has a greater impact on blueberry production than fire intensity (Table 2). Whereas fire intensity is a measure of the caloric energy liberated by the fire front (Alexander 1982), depth of burn integrates the interaction between soil moisture conditions and fire intensity (Miller 1977) and is more closely linked to the response of blueberries to fire than fire intensity.

Since blueberry shoots arise from shallow rhizomes and portions of the above ground stem not killed by the fire (Flinn and Wein 1977; Martin 1955; Minore 1975), deep heat penetration in the humus layers is likely to reduce stem production. Similar conclusions have been reached in Ponderosa Pine (*Pinus ponderosa*) forests where depth of burn influenced greatly understory species regeneration (Armour et al. 1984) which is consistent with the concept that depth of buried propagules, together with heat penetration, is critical in post-fire survival (reviewed by Whittle et al. 1997). In turn, the differences observed in this investigation in post-fire blueberry stem densities, and the negative correlation between stem density and depth of burn may be ascribed to the deleterious effect of fire on the underground rhizomes as was demonstrated on Blue Huckleberry (*Vaccinium globulare*) (Miller 1977).

In practice, blueberry production can be maximized by burning in the spring of every second year, presumably to maintain a high ratio of flower buds to leaf buds (Hall et al. 1972). In this investigation, the number of blueberries/plant, which was hypothesized to be an estimate of the flower bud to leaf bud ratio, was not significantly different among treatments but inversely correlated with fire intensity. These results cannot be explained by conventional thinking regarding flower bud formation (Hall et al. 1972), as the number of blueberries/plant correlated with depth of burn. However, Smith and Hilton (1971) speculated that Lowbush Blueberry performance after fire pruning might result from the stimulative effects of the nutrients in ash deposited on the surface soil during burning. Further investigation is needed to assert the relevance of this hypothesis in blueberry flower biology.

Although this investigation shows that low intensity fires have a positive influence on blueberry production, natural blueberry ecosystems support a variety of wildfire characteristics (Moola et al. 1998; Usui et al. 1995). Hence the continuous effect of repeated fires should be investigated on the long term productivity and biological conservation of such ecosystems. In particular, it will be important to assess the impact of burning every second year, which is the recommended practice, on soil nutrients (Smith and Hilton 1971). Future work should also be conducted to investigate co-management of blueberries with timber values (Duchesne et al. 2001).

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Spring Dispersal Patterns of Red-winged Blackbirds, *Agelaius phoeniceus*, Staging in Eastern South Dakota

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Red-winged Blackbirds (*Agelaius phoeniceus*) are very abundant summer residents throughout the Prairie Pothole Region of central North America. In late summer they assemble in post-breeding flocks that cause significant amounts of agricultural damage, particularly in sunflower fields near natal sites. In April 2001, we aerially color-marked ~370 000 Red-winged Blackbirds near Badger, South Dakota (44°48'N, 97°21'W), to determine if migrants staging here were summer residents in sunflower production areas ~350 km to the northwest. We measured patterns of migratory dispersal by collecting birds in 54 randomly selected blocks in the northcentral U.S. and the Prairie Provinces of Canada. The marked specimens ($n = 33$) were categorized into three polygons based on analyses of banding and re-sighting data and proximity to concentrated sunflower production. We estimated that 82% of the migrants that had staged in eastern South Dakota resided within or on the periphery of the sunflower growing area. These birds probably stay near their breeding territories until at least late August and cause early damage to sunflower, which comprises the majority of damage. Resident birds in Alberta and most of Saskatchewan (18%) might arrive too late in the damage season to impact the sunflower crop significantly.

Key Words: *Agelaius phoeniceus*, Red-winged Blackbird, breeding range, color-marking, dispersal patterns, northern Great Plains, spring migration, sunflower damage.

Several million hectares of wetlands have been drained in the Prairie Pothole Region (Dahl 1990*), but high densities of semipermanent wetlands remain in North Dakota (0.88/km^2, Reynolds et al. 1997*). These are preferred nesting habitat of Red-winged Blackbirds (*Agelaius phoeniceus*) and make North Dakota the center of abundance for this species. During the mid-1990s, the breeding population in North Dakota started gaining rapidly in size. Red-winged Blackbird indices from the North American Breeding Bird Survey (BBS) are at historical highs for the state (Figure 1). From 1994-2002 North Dakota's average BBS index of all routes in the Prairie Pothole Region ranged from 199 to 250 Red-winged Blackbirds per route. North Dakota led all other U.S. states and Canadian provinces during this period in annual indices of Red-winged Blackbirds (Sauer et al. 2004*). Conflicts between wildlife and agriculture often occur because of local overabundance (Garrott et al. 1993; Conover 2002), and the growth in numbers of Red-winged Blackbirds has exacerbated a long-term struggle between sunflower producers and blackbirds (Linz and Homan 1998). Oilseed sunflower is a preferred food of Red-winged Blackbirds (Linz et al. 1984; Homan et al. 1994). It is also an important economic crop in North Dakota. In 2001, 75% of total oilseed sunflower production in North America came from North Dakota (National Agricultural Statistics Service 2004*). With increased depredation pressure on the crop caused by population expansion of Red-winged Blackbirds, many growers probably dropped sunflowers from their field rotations (Lamey and Luecke 1994). Since 1995, the number of sunflower fields has steeply declined in central and southeastern North Dakota, areas renowned for their high levels of sunflower production (National Agricultural Statistics Service 2004*).

Statewide field damage surveys have that blackbird damage to sunflower ranges from $4 to 11 million (U.S. dollars) in the Prairie Pothole Region (Hothem et al. 1988). Based on current population estimates and bioenergetic models, Red-winged Blackbirds cause $3 million of the $5.5 million lost yearly to blackbirds in the core area of sunflower production (Peer et al. 2003). Most of the damage occurs between mid-August and early September, when the calorie content of immature sunflower achenes is low and the birds must eat more to reach satiation (Cummings et al. 1989; Conner and Hall 1997). During this early damage period, when >75% of total damage occurs, Red-winged Blackbirds account for 80% of the blackbird species observed in sunflower fields (Cummings et al. 1989). This period is before *en masse* blackbird migration, and the majority of these birds are of local origin. Most will remain within 200 km of their natal sites until molt completion (or near completion) in late August and early September (Dolbeer 1978; Besser et al. 1983; Linz et al. 1983). The damage can be quite serious in central and southeast North Dakota and northeast South Dakota, areas of concentrated production of sunflowers (National Agricultural Statistics Service 2004*) and

plentiful wetlands to attract nesting Red-winged Blackbirds (~22 breeding pairs/km^2, Linz et al. 2002). By late summer, the Red-winged Blackbird population responsible for most of the sunflower damage in the Prairie Pothole Region is about 39 (±8.8) million (Peer et al. 2003).

Reducing excessive field damage (e.g., >10% per field) has proven an enormous challenge. The U.S. Department of Agriculture (USDA) uses an integrated management approach of lethal and nonlethal methods. Most of the available methods are used infrequently because of unmanageable logistics, little or no efficacy, or low cost:benefit ratios (Linz and Hanzel 1997). Mechanical frightening agents (e.g., scarecrows, pyrotechnics, and propane cannons) help alleviate light predation pressure, but only work effectively if the duration of the damage period is less than the habituation period (Cummings et al. 1986). Unfortunately, blackbirds habituate quickly to frightening agents, particularly if the crop is a preferred food in an area of limited alternate foods (Ward 1979). The taste repellent, methyl anthranilate, is also used by producers, but the concentration in the commercial product (BirdShield™) is below the known repellency threshold, despite the formulation's high cost (Werner et al. 2005). Experiments with avicide were tried in sunflower fields with ongoing damage. Avicide-treated rice (DRC-1339) was placed in small plots opened in the fields. This approach failed because (1) blackbirds foraged almost exclusively on the standing heads of sunflower and would not go to the ground to forage in the plots, (2) precipitation necessitated numerous rebaitings, and (3) nontarget avian risks increased substantially over the baiting period because of migration (Schaaf 2003; Linz et al. 2000). Two nonlethal methods showing some promise are reduction of dense stands of cattail (*Typha* spp) in wetlands near sunflower (Linz et al. 2004*a*) and strategic placement of lure crops to attract foraging blackbirds away from sunflower fields (Linz et al. 2004*b*). Cattail management has been a USDA program for over 10 years. The program is small compared to existing coverage of cattail (Ralston et al. 2004); and it also faces year-to-year logistical challenges because of instability in roost locations across years combined with cattail's ability to rapidly invade, colonize, or re-colonize wetlands (Homan et al. 2003). Research on efficacy of lure crops is just beginning and time will be needed to assess this method.

Sometimes population management may be the most realistic and effective method for reducing persistent damage caused by overabundant wildlife populations (Garrott et al. 1993). The definition of overabundance is subjective and based upon one's interests, likes, and dislikes; and therefore is controversial. It has been defined generally as that point of abundance where all positive values of the species have been overwhelmed by negative values created by the sheer numbers of individuals (Conover 2002). The definition implies both a spatial and temporal component, as populations are seldom ubiquitous or always aggregated. The definition is fitting, at least from an agricultural perspective, in the sunflower growing areas of North Dakota and northeastern South Dakota. The USDA has drafted an Environmental Impact Statement (EIS) that addresses the conflict between sunflower producers and blackbirds in North Dakota, South Dakota, and Minnesota (Federal Register 2001*). Several management options were included in the draft EIS. The research described herein addresses one of the options being considered: population management of spring migrating Red-winged Blackbirds in northeastern South Dakota. This part of South Dakota is one of the most northward sites where the population is still grouped together enough to make population management a feasible alternative.

Because blackbird damage to sunflower is a localized phenomenon occurring within the broader region of the northern Great Plains (Peer et al. 2003), it is necessary to identify specific origins of local populations before implementing any strategy of population management. Although leg-banding has provided valuable insights into migratory timing and dispersal of Red-winged Blackbirds (Dolbeer 1978), this method draws its samples randomly from regional populations. Moreover, it is labor intensive in both its capturing and ringing methods; these drawbacks combined with natural annual mortality of Red-winged Blackbirds cause data to be parsed over several years because of extremely low rates of band returns (<0.5%, Besser et al. 1983; Gammell et al. 1986; Stehn 1989). An alternative method of tracking movements, aerial mass color-marking, provides a means for rapid accumulation of data on movements of local populations within a single season framework. Recovery rates from mass color-marking projects depend on the number marked compared to the size of the study population (Johns et al. 1989); however, thousands of birds can be marked in a single application often yielding a rate of return 10 to 20 times that of leg-banding. Aerial mass color-marking has been used to track spring movements of Red-winged Blackbirds from northeastern Missouri and eastern South Dakota (Knittle et al. 1987; Knittle et al. 1996), short late-summer movements of Red-winged Blackbirds in central North Dakota (Linz et al. 1991), and movements of Red-winged Blackbirds between winter roosts in the southcentral U.S. (Harsch 1995*). The marking formulation is environmentally safe at the concentrations used (Bills and Knittle 1986; Knittle and Johns 1986).

In April 2001, we used aerial mass-marking to identify migrating Red-winged Blackbirds staging in large cattail-dominated wetlands in northeastern South Dakota. Millions of spring migrating blackbirds annually stage at this traditional stopover site between late March and April (Sawin 1999). Our objective was to assess migratory dispersal to breeding territories north of the marking site. Previous research has shown that

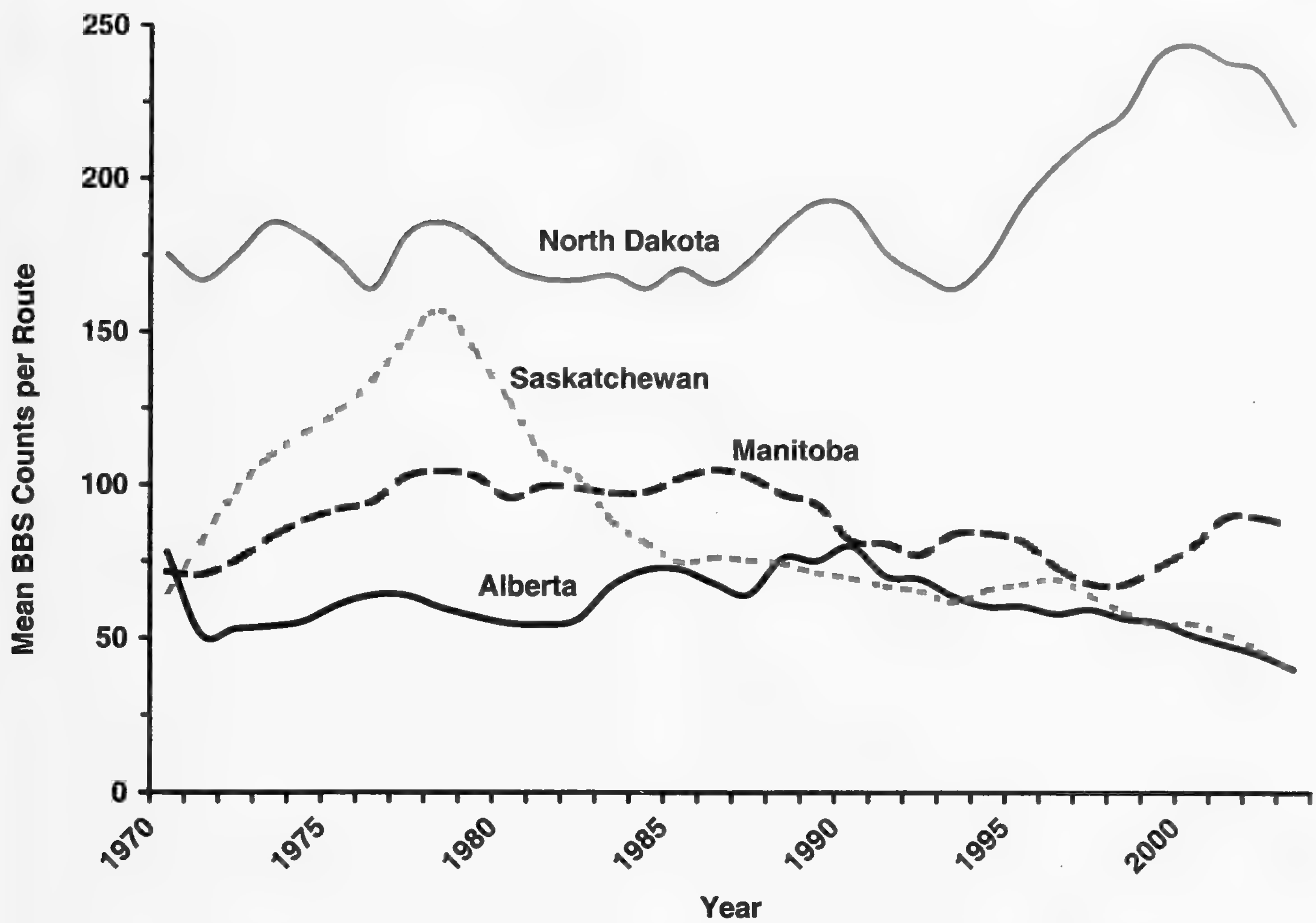

FIGURE 1. Three-year rolling averages of indices from the North American Breeding Bird Survey from 1967 to 2003. The indices are from routes in the Drift Prairie, Glaciated Missouri Plateau, and Aspen Parklands, which are the three major physiographic regions in the Prairie Pothole Region used most frequently by Red-winged Blackbirds.

color-marked male Red-winged Blackbirds staging in eastern South Dakota during spring were in part destined for breeding grounds in or near concentrated sunflower production; however, these data were collected over 15 years ago (Knittle et al. 1987; Knittle et al. 1996). Population management programs, when used at sites far from the locality where actual damage occurs, must be based on a thorough and contemporary knowledge of movements of individual populations (Dolbeer 1978). We believed it necessary to replicate the marking studies because changes may have occurred in migratory patterns. Additionally, no data exist on dispersal movements of females, and these data would increase our understanding of the population's migration patterns.

Methods

Marking

During March 2001, we monitored cattail-dominated wetlands in six counties in eastern South Dakota for arrival of migratory flocks of blackbirds. Three wetlands held migratory roosts large enough (>10 000 birds) to warrant aerial mass-marking. All three roosts were within a 32-km radius of Badger, South Dakota (44°48'N, 97°21'W). Roost size was estimated by counting blackbirds as they entered the roost on the evening of the spray (Meanley 1965; Arbib 1972). Species compositions and sex compositions were estimated by randomly selecting and identifying groups of individual birds as they entered (Dolbeer et al. 1978). A fixed-wing agricultural spray plane applied the marker near dark at an altitude of 20–30 m (Knittle et al. 1987). The following morning we collected birds as they departed the sprayed roost and later examined them for fluorescent marks using a long-wave (360 nm) ultraviolet light. We calculated the number of marked male and female Red-winged Blackbirds in the roost by multiplying the proportion of marked birds in the sample by the estimated number of males and females using the roost on the night of the spray.

The marker formulation was a 416-L solution consisting of 208 L Carboset® (an acrylic adhesive; Noveon™ Incorporated, Cleveland, Ohio), 102 L food-grade propylene glycol, 7.7 kg fluorescent organic pigment (DayGlo® Color Corporation, Cleveland, Ohio), 1 L each of a defoamer and surfactant, and 106 L water (Knittle et al. 1996). We used CP® nozzles set at 5 (400 micron droplets). Spray volume was 28L/ha delivered at 1.8 kg/cm^2. In spray form the solution dries in 2-3 minutes adhering to the feather surface.

Knittle and Johns (1986) found that 5% of marked birds lost their marks within six weeks; however, particles lodged in the barbules can remain until molt (Knittle et al. 1996; Otis et al. 1986).

Sampling and Collections

We grouped the study area into 140 blocks, each consisting of four 1°-latitude × 1°-longitude units. Two units were randomly selected from each block. To ensure adequate sample sizes per effort, only those units within regions that averaged ≥30 Red-winged Blackbirds per BBS route were selected (Sauer et al. 2004); 37 units in Canada and 19 units in the U.S. were chosen in this manner. No units south of the 1° × 1° unit containing the marking sites were sampled. The sample units covered an extensive area (>1.0×10^6 km^2) bounded by 44–57° N latitude and 95–119° W longitude (Figure 2). Southwestern North Dakota, central Minnesota, central and western South Dakota, and southeastern Montana were excluded because BBS counts were ≤30 (Sauer et al. 2004).

We assigned the 1° × 1° units to one of three dispersal polygons: core, peripheral, and outside-peripheral (Figure 2). The shape and area of the polygons were based on an analysis of banding and re-sighting data, physiography, and proximity to the area of concentrated sunflower production (Stehn 1989). The core polygon encompassed the breeding range of birds having a high probability of causing early damage to sunflowers. The peripheral polygon contained the surrounding breeding range of birds that were capable (with only short pre-migratory movements) of entering the core area during the early damage period (mid-August – early September) (Dolbeer 1978; Gammell et al. 1986). The outside-peripheral polygon contained the birds farthest removed from the core area and encompassed the rest of the study area not covered by the core and peripheral polygons. The 1° × 1° units were placed in core and peripheral polygon categories if any of the unit's area intercepted the polygon's boundary. We used a GIS to place the polygons on a georeferenced grid of the 1° × 1° units.

We used shotguns (12-gauge with either #6 or #7½ steel shot) to collect male and female Red-winged Blackbirds on breeding territories during June in the U.S. and June and early July in Canada. The wings were removed from the specimens and placed in an envelope with the GPS coordinates of the collection site. The wings were later viewed for fluorescent pigments using a 360-nm ultraviolet lamp under 1.75 magnification. The markings on tagged birds are usually subtle and invisible to the naked eye under natural light. To eliminate false positives, only splash marks and individual particles firmly attached to the feathers were considered conclusive evidence of a valid mark (Knittle et al. 1987). Blood samples were removed on-site from randomly selected specimens and used for microsatellite genetic analysis in a separate study (Williams et al. 2004). The wings were frozen and shall be kept for future research on primary feather chemistry and its relationship to geographic origins (Edwards and Smith 1984).

The data were analyzed using descriptive statistics, likelihood ratio chi-square analyses (*G*-tests), and non-parametric tests. We used *G*-tests to assess differences between (1) the proportion of marked birds (sexes combined) in the sample with the expected proportion of marked birds in the study area; (2) the proportions of marked males and females in the sample with the expected proportions of marked males and females in the study area; and (3) the proportions of marked birds within core, peripheral, and outside-peripheral polygons. The first two tests used extrinsic expected frequencies based on estimates of marking efficiency at the staging site and population size in the study area during the breeding season. The third comparison used intrinsic frequencies generated exclusively from the collections (Sokal and Rohlf 1981). Population size in the study area was estimated using a combination of stable age structure analysis from banding data and linear regression analysis of BBS indices and independently determined density estimates (Stehn 1989). The resultant regression equation was $Y = 0.3X$, where X was the average BBS count within each ecological stratum in the study area and Y was the population density per km^2 (*see* Aldrich 1963; Robbins et al. 1986). We used the Wilcoxon Rank Sum test to compare ranked differences between males and females in distances traveled from the marking site to the collecting sites. Distance measurements were made using a GIS.

Results

We applied fluorescent marker seven times, tagging an estimated 235 500 male and 131 100 female Red-winged Blackbirds over the period 1-23 April. This period covered the Red-winged Blackbird migration through eastern South Dakota in 2001. We collected 2398 males and 2060 females on breeding territories, of which 33 (0.74%) were marked (Table 1). The overall recovery rate of 0.74% was similar to the expected recovery rate of 0.96% ($G = 1.1$, $P = 0.30$), based on total number of birds marked in April and the estimated population size of breeding Red-winged Blackbirds in the sampled collection area (38.1×10^6, *from* Stehn 1989) which included the population in the outside-peripheral polygon. The ratio of marked males : females in the sample ($f = 23 : 10$) was near the expected ratio of 22 : 11 ($G = 0.07$, $P = 0.80$). Proportions of marked birds collected in the three polygons differed ($G = 6.44$, $P = 0.04$), with the percentages of marked birds in the core polygon (1.03%) and peripheral polygon (0.93%) nearly three times greater than the percentage collected in the outside-peripheral polygon (0.35%) (Table 1). The outside-peripheral polygon contributed 69% of the total *G*-value. Of the 33 marked recoveries, 15 (46%) were collected in the core polygon and 12 (36%) were collected in the peripheral polygon.

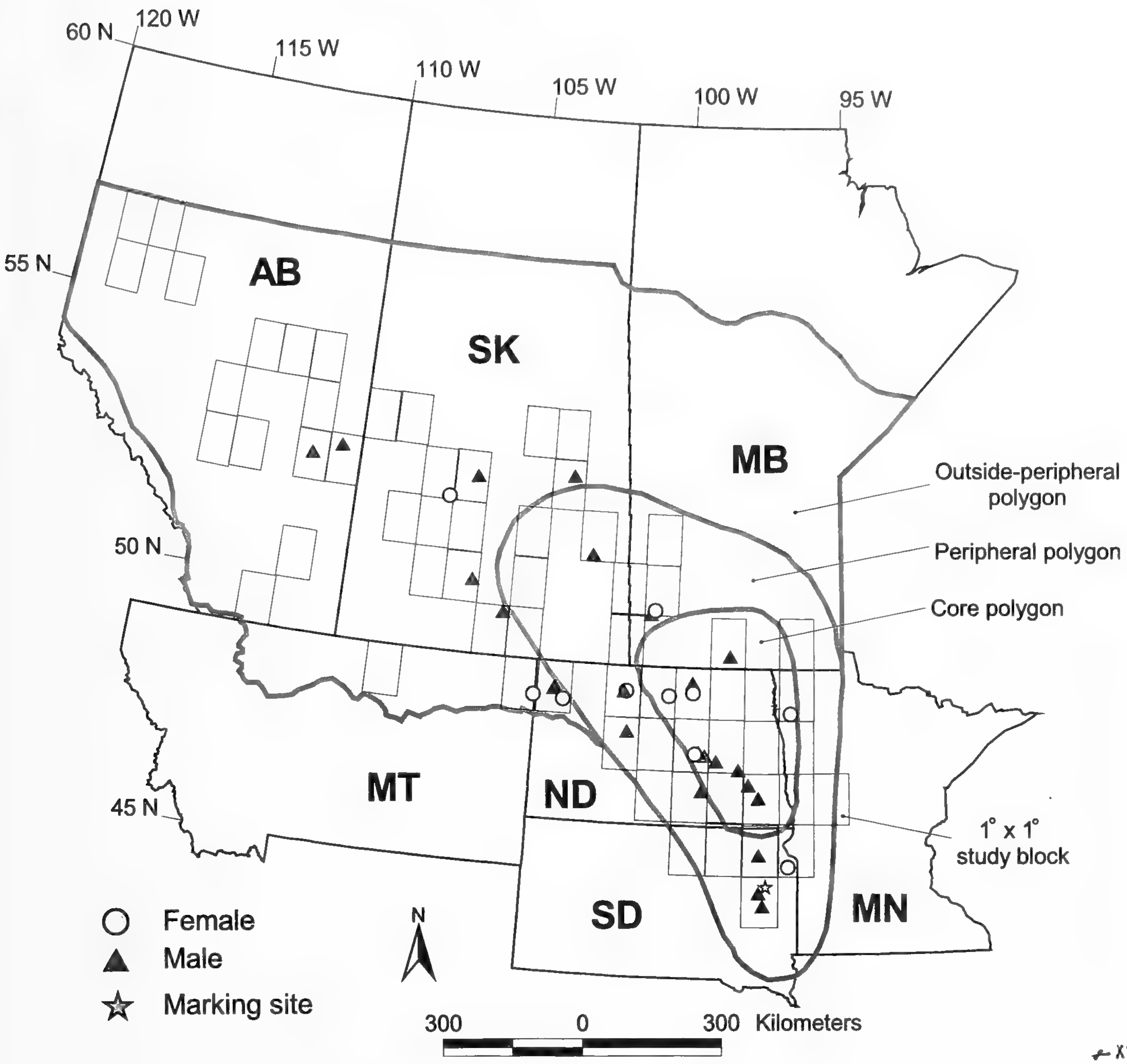

FIGURE 2. Locations of 33 marked Red-winged Blackbirds (in relation to core, peripheral- and outside-peripheral polygons) after dispersing from a spring staging site in eastern South Dakota in April 2001.

TABLE 1. Color-marked male (♂) and female (♀) Red-winged Blackbirds collected during June and July 2001 in core, peripheral, and outside-peripheral polygons after migratory dispersal from a staging site in eastern South Dakota during April 2001.

Polygon	Number units[a]	Number Collected			Number Marked			Percent Marked		
		♂	♀	Total	♂	♀	Total	♂	♀	All
Core	14	793	668	1 461	9	6	15	1.13	0.90	1.03
Peripheral	15	681	605	1 286	10	2	12	1.47	0.33	0.93
Outside	27	924	787	1 711	4	2	6	0.43	0.25	0.35
Total	56	2 398	2 060	4 458	23	10	33	0.96	0.48	0.74

[a] No birds were collected in two units

No marked birds were collected north of 53° N. Recovery distances were similar between sexes (T = 0.18, P = 0.86), with the median location 519 km (range: 20–1353) from the marking sites (48°23'N, 100°27'W). The median azimuth from the marking sites was 325°. The median distance and direction of marked females placed them on the northwestern side of the core polygon (48°23'N, 100°27'W; whereas, males were 70 km due west (48°30'N, 101°23'W), in the peripheral polygon. For all recoveries combined, the median location was 50 km northeast of Minot, North Dakota (48°14'N, 101°18'W).

Discussion

The seven sprays were evenly distributed throughout the migratory period and probably yielded an accurate depiction of the migratory distribution patterns of Red-winged Blackbirds. Similar to the results of previous banding and color-marking experiments in eastern South Dakota, our data showed that most birds followed the Prairie Pothole Region as they traveled northwest to their breeding territories (Besser et al. 1983; Knittle et al. 1987; Knittle et al. 1996). Although Red-winged Blackbirds are not confined to breeding in this region, they are found here in their highest densities. A statewide population census of breeding birds in North Dakota showed that the Prairie Pothole Region (comprised of several physiographic regions, but mainly the Drift Prairie and Glaciated Missouri Plateau) contained 70% of the state's Red-winged Blackbird population (Stewart and Kantrud 1972).

Unlike parameters such as median distance and direction, both of which can be influenced by differences in breeding densities over the study area, the proportions of marked birds within the three polygons were distribution measures mathematically independent of density. It was thus possible to consider our results as reflections of behavioral phenomena, such as fidelity to migratory pathways and philopatry. The marked population was apparently not distributing itself randomly in the study area. The low proportion of marked birds in the outside-peripheral polygon suggested that eastern South Dakota may be used mainly by migrants already near their final destination, and as a result, traveling relatively short distances after departure from the staging site. We speculate that other staging sites might exist (perhaps much farther to the west), and these should have birds destined for breeding territories in Montana, southern Alberta, and Saskatchewan. Marking of large roosts farther west (for example, a large blackbird roost exists near Great Bend, Kansas [38° 22'N, 98° 49'W]) may demonstrate that western migratory pathways exist distinct from the one used by blackbirds in eastern South Dakota. Certainly, the very low proportion of marked birds in the outside-peripheral polygon, compared to the other two dispersal polygons, suggests a different population of birds.

There were two other marking studies done in the general vicinity of our marking site. These were done at Lake Thompson, South Dakota (44°23'N, 97°33'W), approximately 30 km to the southwest. Both were similar in design, scope, and sampling effort to our study, except that only males were collected. One study was conducted in 1983 (Knittle et al. 1987), the other in 1985 (Knittle et al. 1996). Even though geopolitical boundaries were used to analyze returns instead of dispersal polygons, comparisons of results among and between studies can still be made. Results were similar between our study and the 1983 study in two important facets: (1) the recovery rate of marked birds in Canada was substantially lower than the U.S. recovery rate (4.4 *vs.* 7.0%, Knittle et al. 1987), and (2) proportions of marked birds collected in western North Dakota, central North Dakota, and northeastern South Dakota were greater than other regions. By contrast, results diverged in the 1985 study, both from our results and from those from the 1983 study. The expected rate of recovery in the 1985 study was much less than the observed recovery rate (5.2 *vs.* 14.6%, Knittle et al. 1996). To obtain a 14.6% recovery rate, the male population would have had to have been 6.7×10^6, a number 65% lower than what was estimated in the study area during that time (19.0×10^6, Stehn 1989). Saskatchewan's Red-winged Blackbird population had indeed been in steep decline for nearly a decade, as evidenced by BBS indices (Figure 1); however, trends for Alberta, Manitoba, and North Dakota were either stable or increasing. It is unlikely for such a conspicuous species that a 65% decline would be missed in the BBS surveys. Of course, the number of birds marked in 1985 could have been underestimated by this magnitude, but an even more anomalous result in the 1985 study argues against this; the percentage of marked birds in Canada was greater than the percentage marked in the Prairie Pothole Region below 49° N (17 *vs.* 16%). Usually, recovery rates are inversely related to the distance traveled from a marking site because unmarked populations arriving by other routes from other areas dilute the proportion of marked birds. Although it is conceivable that the Red-winged Blackbird population marked at Lake Thompson in 1985 migrated beyond traditional nesting areas and immigrated into Canada, perhaps seeking better wetland conditions, band recoveries collected over several decades have shown that Red-winged Blackbirds usually return to within 100 km of their natal sites (Nero 1956; Dolbeer 1978). If Red-winged Blackbirds were not philopatric, but nomadic or irruptive, we contend that large fluctuations in BBS counts would occur among physiographic regions comprising the Prairie Pothole Region. No significant correlations existed in yearly changes in BBS indices between North Dakota and the three Prairie Provinces within our study area, and perusal of average BBS indices over a 36-year period does not seem to indicate irregular migratory

behavior (Figure 1). The extraordinarily high overall recovery rate of marked birds in the 1985 study may have resulted from improper identification of marks (i.e., false positives) caused by environmental contamination with fluorescence pigments used for identifying insecticide formulations and fertilizers (Knittle et al. 1987). We believe that our data from 2001 and the data from the 1983 study have provided the most accurate analyses of dispersal patterns of migrating Red-winged Blackbirds in eastern South Dakota.

Summary and Conclusions

In landscapes with numerous wetlands, blackbird damage to sunflowers averages ≥5% per field. One-quarter of the fields receive >10% damage (Linz et al. 2000). At the 10% damage level, agricultural producers start dropping sunflower from their crop rotations and replacing it with other oil crops, such as soybean and canola (North Dakota Agricultural Statistics 1990*; Lamey and Luecke 1994). There is no evidence that the rapid population growth of Red-winged Blackbirds has directly affected other bird species; however, the potential for indirect effects exists. Sunflower fields were used by 49 nonblackbird species, representing all the major feeding guilds, during the late-summer and early fall migrations (Schaaf 2003). Sunflower fields have several characteristics that could make them excellent migratory stopover sites for rest, cover, and procurement of energy reserves (Hutto 1998; Petit 2000). First, they provide large blocks of sturdy herbaceous cover with a dense canopy and rank understory in a landscape that by mid-August is mostly barren north of 46°N because of the harvest of small grains (Schaaf 2003). Second, sunflower fields provide a diverse selection of foods, including seeds of weedy plants in the furrows and numerous invertebrates in and around the fields (Schulz 1978; Charlet et al. 1997; Schaaf 2003). This attracts avian granivores and insectivores (and of course, the carnivores). Soybean and canola fields, which often replace sunflower, have neither the beneficial vegetative structure nor the energy and are a less productive habitat for birds (Linz et al. 2004*b*). Moreover, these crops are "clean cropped," unlike sunflower, which is often not plowed until May of the following year. Sunflower stubble was used by 33 species of migrating birds during early spring in North Dakota (Galle et al. 2004). It was used more frequently during spring migration than fields of soybean, small grain, corn, and sorghum. Thus, loss of sunflower fields in the Prairie Pothole Region could have unforeseen ecological impacts on migrating nonblackbird species.

We estimate that 82% of the Red-winged Blackbirds that stage in eastern South Dakota during spring migration reside either within or on the periphery of the sunflower growing area. If population management of the spring breeding population in the northern Great Plains is deemed the best of the EIS alternatives, we suggest that the most efficacious strategy would be to manage the population in eastern South Dakota. Lastly, it may be possible to avoid impacting the Canadian migrants, which comprised 18% of the birds staging in eastern South Dakota, by not applying management over the entire migration. Canadian Red-winged Blackbirds should be among the last of the regional populations of Red-winged Blackbirds to arrive at the staging site (Weatherhead and Bider 1979). The arrival of Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*), a nontarget blackbird species, usually signifies that the Red-winged Blackbird migration is nearing its end and may be a good indicator to cease management operations.

We recommend future research on (1) genetic markers to identify local populations of Red-winged Blackbirds residing in Canada and the U.S.; (2) color-marking spring migrants in flyways farther west; (3) the relationship between timing of arrival at staging sites and distance traveled to breeding territories; and (4) color-marking pre-migratory roosts [or other means of identification, such as genetics or mineral analyses of primary feathers] northwest of the core sunflower growing area prior to fall migration.

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Changes in Loon (*Gavia* spp.) and Red-necked Grebe (*Podiceps grisegena*) Populations in the Lower Matanuska-Susitna Valley, Alaska

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More than two-thirds of the human population of Alaska resides in the south-central portion of the state, where its continued growth is likely to affect some wildlife populations negatively. To assess changes in waterbird populations in this region, we compared counts of Common Loons (*Gavia immer*), Pacific Loons (*G. pacifica*), and Red-necked Grebes (*Podiceps grisegena*) made on Matanuska-Susitina Valley lakes. In general, the number of lakes occupied by loon or grebe pairs decreased between 1987 and 1999. Decreases in the number of lakes occupied by Common Loons were less drastic in the northwest region of the study area than in the southeast region; human development is greater in the southeastern portion of our study area. Contrary to lake occupancy, the percentage of lakes that fledged Common Loon chicks remained stable between years. Because the human population is expected to continue to grow, proactive management of lake use and lakeshore development, coupled with monitoring of loon and grebe occupancy and productivity, is needed to ensure the persistence of these waterbird populations in the lower Matanuska-Susitna Valley.

Key Words: Common Loon, *Gavia immer*, Pacific Loon, *Gavia pacifica,* Red-necked Grebe, *Podiceps grisegena*, breeding occupancy, productivity, south-central Alaska.

The stability of many bird populations mainly depends on the stability of the environments they inhabit (Newton 1998). Nesting loons (*Gavia* spp.) and grebes (*Aechmophorus* spp., *Podiceps* spp.) are often negatively affected by habitat degradation and increased levels of human-related disturbances (Riske 1976; McIntyre 1978; Evers 2003). Common Loons (*Gavia immer*), Pacific Loons (*G. pacifica*), and Red-necked Grebes (*Podiceps grisegena*) breeding on lakes in the Matanuska-Susitna Valley (Mat-Su Valley), Alaska, are encountering many changes to their local environment. The area's human population has tripled in the last two decades, and the current annual growth rate is 3.3% (McKibben and Nelson 1999*). Within the Mat-Su Valley, population growth has been greatest in the southeast, the area closest to Alaska's largest city (Anchorage; McKibben and Nelson 1998*, 1999*). The growing human population in the Mat-Su Valley has begun to encroach upon the freshwater habitat favored by breeding loons and grebes. Development of lake shorelines for houses and increased recreational use of lakes are suspected of having detrimental effects on loon and grebe populations in the Mat-Su Valley (Tankersley 1987*, Fair 1998*).

Concern over the susceptibility of local loon populations to anthropogenic pressures prompted the formation of a volunteer program, the Alaska Loon Watch, in 1985. Under the direction of the Alaska Department of Fish and Game (ADF&G), volunteers collected data on loon and grebe presence and breeding activity on lakes throughout the Mat-Su Valley (see Fair 1998*). Using data collected through the Alaska Loon Watch program and our own observations, we assessed changes in lake occupancy, distribution, and productivity of loons and grebes breeding in the Mat-Su Valley between 1987 and 1999. Based on the significant growth of the human population in the region, we predicted that lake occupancy and productivity by loons and grebes would have decreased over time. Furthermore, we predicted that the distribution of loons and grebes would shift spatially from southeast to northwest in response to corresponding changes in intensity of shoreline development and lake recreation.

Study Area

The Mat-Su Valley of south-central Alaska lies between the Matanuska and Susitna rivers and borders upper Cook Inlet. Over 1000 lakes, ponds, and wetlands of glacial origin occupy kettles in moraines and ice-stagnation complexes in this 500 km^2 region (Colazzi et al. 1986*). Lakes are classified as oligotrophic or mesotrophic with pH levels conducive to support fish species preyed on by loons and grebes (Ruggles 1991). The elevation of the valley floor ranges from tide level to 400 m, but local relief of the area is

Uplands are dominated by White Spruce (*Picea glauca*), Paper Birch (*Betula papyrifera*), and Quaking Aspen (*Populus tremuloides*); Black Cottonwood (*Populus trichocarpa*) and willows (*Salix* spp.) are common along waterways and on alluvial plains. Maritime influences moderate the climate in the Mat-Su Valley with average mid-summer temperatures of 14°C, annual snowfall of 150 cm, and annual precipitation of about 48 cm. We concentrated our survey effort within the lower Mat-Su Valley, an area bounded by the communities of Palmer to the southeast, Willow to the northwest, Sutton to the east, and the Susitna River to the west (Figure 1).

Methods

We surveyed lakes in late May and late August of 1999 to determine occupancy by loons and grebes and productivity of loons. Because of their smaller size and tendency to linger in aquatic vegetation, productivity of Red-necked Grebes was not recorded. Of

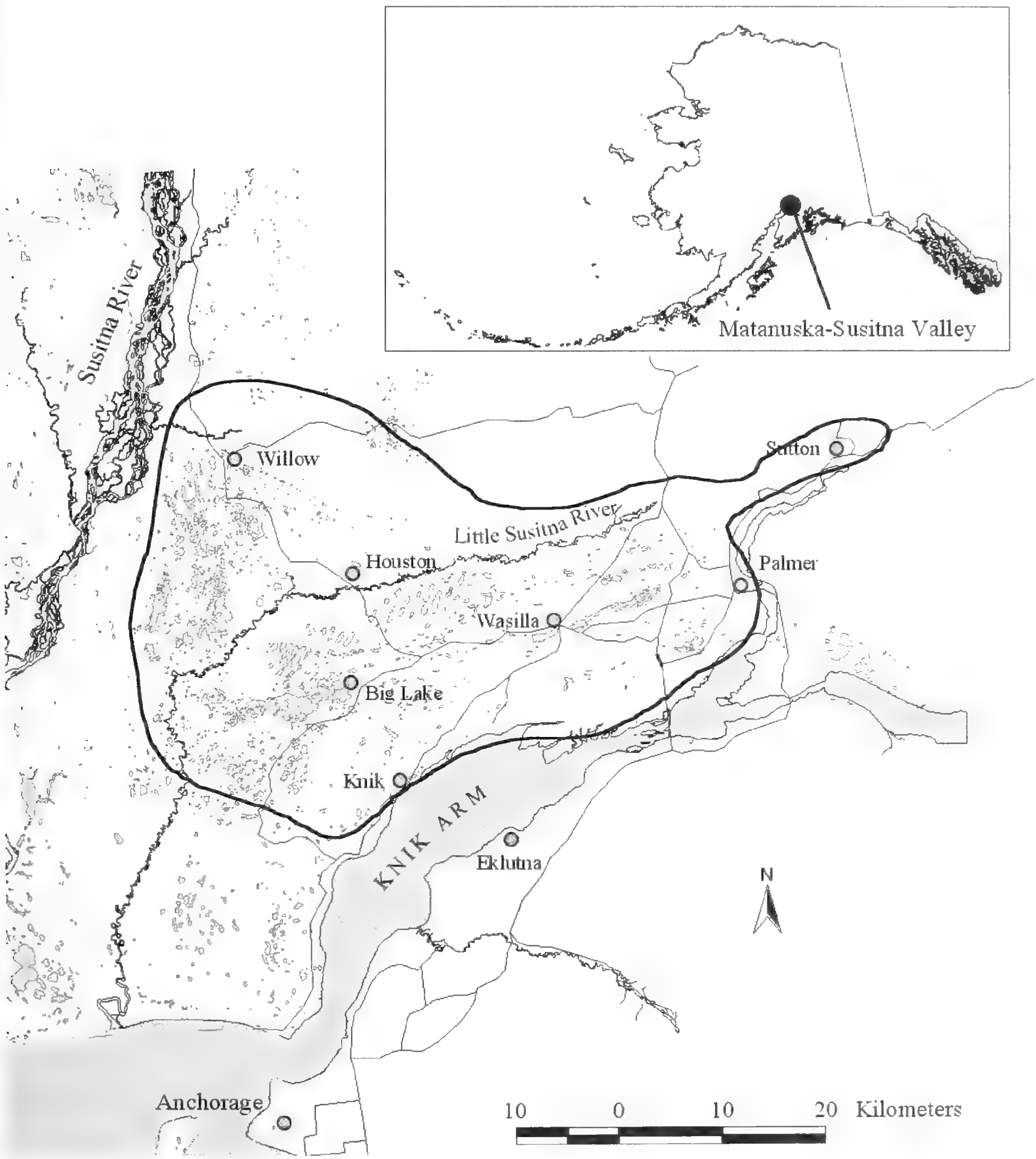

FIGURE 1. Location of the lower Matanuska-Susitna Valley, Alaska, where lake occupancy and productivity of loons and grebes were assessed, in the delineated area, in 1987 and 1999.

219 lakes surveyed in 1987 by biologist Nancy Tankersley (ADF&G) and volunteers of the Alaska Loon Watch program, we determined that 139 lakes had adequate coverage in both years to allow a meaningful comparison. In 1999, observers scanned each lake with binoculars from several vantage points along the lakeshore to ensure complete lake coverage. Lakes were scored for the presence or absence of single loons or loon pairs during late May and for the presence or absence of loon chicks during late August. Field methods were similar in 1987. A lake was considered occupied if a loon pair was found on a lake surveyed on or before 5 July, or if chicks were discovered on the lake. Only lakes surveyed after 25 June were used to determine productivity.

To detect changes in the spatial distribution of loons over the 12-year period. We divided the study area was divided into two regions of differing human population densities. The Little Susitna River runs east to west and divides the study area into southeastern (Wasilla, high human population) and northwestern portions (Willow, low human population). Lake physiographic features are comparable between regions, and lakes vary similarly in size, food availability, and shoreline topography (Ruggles 1991).

We used McNemar's symmetry test for matched pairs to compare temporal and geographic differences in lake occupancy and productivity (Agresti 1996 pages 226-229). Alternative hypotheses were constructed to indicate a decline in parameter estimates between 1987 and 1999; no statistical analysis was conducted when $n \leq 3$ lakes. We used P-values to examine strength of differences between years and regions. Standardized normal standard errors of differences were also calculated (Agresti 1996 page 228).

Results

The number of lakes occupied by any loon or grebe species decreased significantly between 1987 and 1999 across the entire study area (Table 1). Decreases in lake occupancy between years were consistent among Common Loons, Pacific Loons, and Red-necked Grebes (Table 1). Differences in occupancy of lakes by loon or grebe pairs, however, were not uniform among regions of the Mat-Su Valley. Decreases in the number of lakes occupied by any loon or grebe pair and by Common Loons were less drastic in the northwest region of the study area (Willow) than in the southeast region (Wasilla; Table 1), where development is greater. Decreases in lake occupancy by Pacific Loons tended to be greater in the northwest section ($P = 0.1094$), but conclusiveness of results was hampered by small sample sizes (Table 1). Point estimates of decreases in occupancy by Red-necked Grebe pairs were similar between regions, but variability was much higher in the northwest region (Table 1).

Contrary to lake occupancy, the percentage of lakes that fledged Common Loon chicks remained stable between 1987 and 1999. Information on productivity of Red-necked Grebes was not collected in 1987, and sample sizes were too small to permit analysis of changes in productivity for Pacific Loons. Productivity of Common Loons was similar on lakes in both regions of the study area.

Discussion

Temporal and spatial changes in the population distribution of loons and grebes in the Mat-Su Valley from 1987 to 1999 are likely attributable to the concurrent rise and spatial settlement of the human population. Significant declines in lake occupancy by Common and Pacific loons and Red-necked Grebes indicated that fewer birds are establishing breeding territories at area lakes. Most of the lakes that are no longer used by breeding loons and grebes (65%) were located in the southeastern portion of the study area – an area that has also experienced the greatest human population growth. Common Loons have been extirpated from lakes within the nearby Municipality of Anchorage, and Pacific Loon populations are decreasing there (Fair 1998*). Such changes in lake occupancy may be indicative of declining loon and grebe populations or may reflect large-scale emigration due to the loss of suitable nesting habitat. Common Loons inhabiting boreal regions of Alaska, however, appear to be stable (Groves et al. 1996).

Population declines of Common Loons and Red-necked Grebes throughout North America have occurred most frequently at the southern boundaries of their breeding ranges where habitat quality has become marginal owing to development (De Smet 1987; McIntyre 1988). In the Mat-Su Valley, a spatial shift in lake occupancy from southeast to northwest may be linked to habitat quality decreases in the same spatial direction. Habitat in the southeastern portion of the study area is likely poorer in quality compared to the northwest, where fewer people live and more lakes remain undeveloped. The stability of lake occupancy to the northwest implies that habitat quality is optimal, a fact supported by the rapid reoccupation of vacant territories (sensu Newton 1998).

The negative trends in lake occupancy may also reflect changes in the demographics of the Mat-Su Valley loon and grebe populations. Loons and grebes are long-lived species known to return to breed on the same lake territories year after year (McIntyre 1988; Stout and Neuchterlein 1999). The combination of a long lifespan and strong site-fidelity may have caused individuals to occupy lakes that had deteriorated in quality over several years. When existing occupants died or left, the vacancies were not filled, and lake occupancy declined over time. Thus, lakes may have lost loons and grebes not suddenly through abandonment by resident breeders, but by failure of new birds to replace them after the death of residents.

Although habitat in the southeastern region may be less suitable during selection of a territory, loons may remain productive if they choose to nest there. Greater

TABLE 1. Occupancy and productivity of breeding pairs of loons and grebes on lakes in high (Wasilla) and low (Willow) human population regions of the lower Matanuska-Susitna Valley, Alaska, in 1987 and 1999.

Species – stage	Percentages of lakes occupied			Difference (SE)		
area	both years	1987 only	1999 only	1999 – 1987		*P*-value[1]
Any loon or grebe - occupancy						
entire area (n = 86)	67	27	6	-21	(6)	0.0005
Wasilla (n = 52)	71	29	0	-29	(6)	<0.0001
Willow (n = 34)	62	23	15	-8	(10)	0.2905
Common Loon - occupancy						
entire area (n = 63)	59	33	8	-25	(7)	0.0012
Wasilla (n = 36)	58	42	0	-42	(8)	<0.0001
Willow (n = 27)	59	22	19	-4	(12)	0.5000
Pacific Loon - occupancy						
entire area (n = 17)	41	47	12	-35	(17)	0.0547
Wasilla (n = 10)	40	50	10	-40	(21)	0.1094
Willow (n = 7)	43	43	14	-29	(26)	0.3125
Red-necked Grebe - occupancy						
entire area (n = 33)	76	24	0	-24	(7)	0.0039
Wasilla (n = 25)	76	24	0	-24	(9)	0.0156
Willow (n = 8)	75	25	0	-25	(15)	0.2500
Common Loon - productivity						
entire area (n = 34)	24	38	38	0	(15)	0.5775
Wasilla (n = 21)	29	33	38	5	(18)	0.5000
Willow (n = 13)	15	46	38	-8	(25)	0.5000
Pacific Loon - productivity						
entire area (n = 10)	80	0	20	–[2]		–
Wasilla (n = 7)	86	0	14	–		–
Willow (n = 3)	67	0	33	–		–

[1] one-sided test, 1987 > 1999.
[2] small sample sizes precluded reasonable statistical testing.

breeding success for Common Loons in the southeastern region may reflect differences in the age structure of the population. Across numerous species, non-breeders and non-territory holders consist mainly of sub-adult birds (Smith 1976; Birkhead et al. 1986). Because replacements for vacant territories in the northwest are likely drawn from the non-territorial cohorts (Ruggles 1991), these loons would be expected to have lower productivity than experienced territorial loons on southeast region lakes.

Tolerance of human activity by experienced territory holders may also explain the differences in Common Loon breeding success between the regions. Common Loons are known to be relatively flexible in behavior and may acclimate themselves to low-level human disturbance (Titus and VanDruff 1981; Heimberger et al. 1983; McIntyre 1988). Years of breeding experience and gradual habituation to the subtle progression of human disturbance would likely result in higher breeding success for loons that established territories years ago.

Loons may also benefit by nesting in areas where humans are moderately active. Recreational activities and residents who watch over loons may deter predators from taking young or eggs. Reports from Alaska Loon Watch volunteers often include stories of residents protecting adults and chicks by discouraging Bald Eagles and other predators (Tankersley 1987*, Mills, personal observation). This interference, combined with the defensive behavior of an adult loon, may be intense enough to dissuade additional predation attempts.

Changes in the distribution of loons and grebes warrant concern about the future of these populations within the region. The human population is expected to continue to increase in the Mat-Su Valley (Alaska Department of Natural Resources 1998), which could result in further changes to the lake habitat used by loons and grebes. Although degradation of lake habitats are likely widespread across south-central Alaska, only a small portion of North America's populations of Common Loon, Pacific Loons, or Red-necked Grebes occur in south-central Alaska. People residing in south-central Alaska, however, value living with wildlife and believe it makes their community "interesting and special" (Alaska Department of Fish and Game 2000). Therefore, proactive management of lake use and lakeshore development, coupled with continued monitoring of loon and grebe populations, is needed to improve the stability of the freshwater habitats and ensure the continued persistence of loons and grebes in the Mat-Su Valley of Alaska.

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The Barred Owl, *Strix varia* in Alberta: Distribution and Status

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Barred Owl distribution and status in Alberta were investigated using over 300 individual records (1912 through 1999) that were collected from literature, museum/zoo specimens, nest cards, bird surveys, volunteer raptor banders, and naturalists. Barred Owls were distributed throughout much of the boreal forest, aspen parkland, foothill, and mountain ecoregions of Alberta. Fifty-four breeding records (46 nests) were found. Barred Owls were associated with older forests and had a clumped distribution, predominantly along water where larger Balsam Poplar trees provide nesting sites. According to Alberta's "Status of Alberta Wildlife 2000" criteria, the Barred Owl should be assessed as Sensitive. There is no evidence that Barred Owls have expanded their range in Alberta in the last 100 years; rather, they have maintained their distribution.

Key Words: Barred Owl, *Strix varia,* distribution, status, Alberta, volunteer surveys, nests.

The Barred Owl, *Strix varia*, is widely distributed throughout North America, ranging from the east coast to the western Canadian provinces (American Ornithologists' Union 1998; Johnsgard 1988; Mazur and James 2000). It is found from the southern tip of Florida to southeastern Alaska. In Canada, the Barred Owl is a permanent resident in woodlands of British Columbia, through central and western Alberta, central Saskatchewan, south-central and southeastern Manitoba, central and southern Ontario, southern Quebec, New Brunswick, Prince Edward Island, and the Maritime provinces (Godfrey 1986). There is little published historical information available on the Barred Owl in western Canada, except for British Columbia (Boxall and Stepney 1982). However, recent studies have found this owl to be more common in western Canada than originally believed (Campbell et al. 1990; Mazur and James 2000; Mazur et al. 1997; Takats 1998).

The Barred Owl is still considered rare in northern regions of Alberta (McGillivray 1996). It was found in the boreal forest region north of Edmonton, in the foothills/montane forests of western Alberta, and in Jasper National Park. The detailed status and distribution of the Barred Owl, however, is poorly documented in the province (Boxall and Stepney 1982; Kirk and Hyslop 1998). There has been considerable debate over the theory that the Barred Owl has only recently extended its range into the western states, Canada, and Alaska, although their relative rarity in the west has been assumed from the paucity of historical records (Shea 1973; Taylor and Forsman 1976; Leder and Walters 1980; Boxall and Stepney 1982; Sharp 1989; Houston and McGowan 1999). It has also been suggested that their numbers are increasing in the boreal forest due to their increasing tolerance of predominantly coniferous forests (Boxall 1986).

In many parts of its range, the Barred Owl is dependent on large areas of remote forest with mature and old growth trees for nesting, roosting, and foraging (Paris 1947; Elody 1983; Devereux and Mosher 1984; McGarigal and Fraser 1984; Elody and Sloan 1985; Allen 1987; Bosakowski et al. 1987; Johnson 1987; Dunbar et al. 1991; James 1993; James et al. 1995; Mazur et al. 1997; Mazur et al.1998). In the United States it has been reported to nest in interior portions of expansive, mature woodland (Allen 1987). The typical Barred Owl nest is in a cavity in a large living or dead tree or in the top of a broken snag. There are records of Barred Owls using more conspicuous platform nests (i.e., stick nests) built by squirrels or other large birds (Mazur et al. 1997), as well as ground nests (Robertson 1959; Postupalsky et al. 1997), but these are potentially less productive than cavity nests (Postupalsky et al. 1997) and are generally quite rare.

Alberta Environmental Protection (1996) placed the Barred Owl on the Yellow B list in the Status of Alberta Wildlife report. The Yellow B list includes species that are: (1) naturally rare but not in decline, (2) naturally rare and have clumped breeding distributions, or (3) associated with habitats or habitat elements that are, or may be, in decline. The status of Canada's remaining old growth forests is of growing concern because of the high rate of harvest (Ellis 1993). In the year 2000, the Barred Owl was placed on the Sensitive species list (Alberta Sustainable Resource Development 2000).

The first step in managing wildlife populations is having knowledge of distribution and abundance (Mosher and Fuller 1996). The first objective of this paper was to compile all historic Barred Owl records (published and unpublished) for Alberta, in order to determine the past and present distribution in the province. The second, based on recent studies, was to evaluate this species' status and general habitat use (as it relates to status) in Alberta. The third was to establish whether evidence exists to support the suggestion of range expansion into the west.

TABLE 1: Barred Owls banded in Alberta: date, location, age, sex, and name of bander (1966-1999).

Date	Location	Age-Sex*	Number	Bander
May 1966	Edmonton	L-U	3	E. Jones
April 1987	Water Valley	SY-U	1	D. Collister
November 1988	53.4°, 113.5°	U-U	1	F & W
April 1988	Deerland	AHY-F	1	R. Cromie
June 1989	Deerland	L-U	3	R. Cromie
May 1990	Deerland	L-U	1	R. Cromie
May 1991	Niton	L-U	3	H. Pletz/B. Gehlert
May 1991	Deerland	L-U	3	R. Cromie
May 1992	Deerland	L-U	3	R. Cromie
May 1994	Millarville	AHY-F	1	D. Collister
June 1994	Tawatina	L-U	1	R. Cromie
June 1994	Uncas	L-U	1	R. Cromie
June 1994	Calling Lake	AHY-F	1	D. Stepnisky/G. Court
June 1995	Solomon Creek	AHY-F	1	L. Takats
August 1996	Gregg Lake	AHY-U	1	L. Takats
May 1995	Water Valley	AHY-F	1	D. Collister
May 1995	Water Valley	AHY-M	1	D. Collister
May 1995	Uncas	AHY-F	1	R. Cromie
May 1995	Uncas	L-U	2	R. Cromie
May 1995	Tawatina	L-U	3	R. Cromie
November 1995	Redwater	AHY-M	1	T. Roper
November 1995	51.1°, 114.2°	U-U	1	G. Halmazna
April 1995	Calling Lake	AHY-M	1	G. Court
June 1995	Calling Lake	AHY-F	1	R. Sissons/G. Court
June 1996	Tawatina	AHY-F	1	R. Cromie
June 1996	Tawatina	L-U	3	R. Cromie
May 1996	Calling Lake	AHY-M	1	B. Olsen/R. Sissons
May 1996	Calling Lake	AHY-M	1	B. Olsen/R. Sissons
May 1996	Calling Lake	AHY-F	1	B. Olsen/R. Sissons
June 1996	Calling Lake	AHY-M	1	B. Olsen/R. Sissons
July 1996	Calling Lake	AHY-M	1	B. Olsen/R. Sissons
August 1996	Calling Lake	AHY-M	1	B. Olsen/R. Sissons
May 1997	Tawatina	L-U	2	R. Cromie
May 1998	Calling River	L-U	1	R. Cromie
May 1998	Calling Lake	L-U	2	R. Cromie
June 1998	Uncas	L-U	3	R. Cromie
June 1999	Uncas	L-U	3	R. Cromie
June 1999	Vinca	L-U	4	H. Pletz

* Age – L=nestling/fledgling, AHY=after hatch year, SY=second year, Sex – U=unknown, M=male, F=female

Methods

Information on Barred Owls in Alberta was collected from a variety of sources, which included: published literature, museum collections (National Museum of Canada, National Museum of Natural Sciences (now Canadian Museum of Nature), American Museum of Natural History, Cornell University Museum of Vertebrates, Royal Ontario Museum, University of Calgary Museum of Zoology, University of Alberta Museum of Zoology, Provincial Museum of Alberta, Alberta Breeding Bird Atlas (Federation of Alberta Naturalists), Avian Raptor Nest Cards (Alberta Sustainable Resource Development/Beaverhill Bird Observatory 1999*), banding records (Canadian Wildlife Service Bird Banding Office), and personal communications with Provincial and National Parks personnel. Records from the following volunteer programs were also collected: Alberta Bird Records 1983-1988 (Alberta Ornithological Records Committee), Breeding Bird Surveys, Christmas Bird Counts and May Species Counts, volunteer owl survey programs (Edmonton Owl Prowl, Alberta Owl Prowl, Alberta Nocturnal Owl Survey), dead raptors turned in to Alberta Sustainable Resource Development, and unpublished data including field notes.

All georeferenced Barred Owl sightings and nest locations were entered into the Biodiversity Species Observation Database (BSOD) (Alberta Sustainable Resource Development/Alberta Conservation Association 1998*). Maps comparing distributions from 1912 to 1975 and 1976 to 1999 were created in ArcView (ESRI GIS Mapping and Software).

FIGURE 1. Photo of a Barred Owl pausing before entering a typical nesting cavity (photo by Gordon Court).

Results

Of 320 reports of Barred Owls, 297 of these were entered into the BSOD database (23 records lacked information on date, location, and/or observer). The first record of a Barred Owl in Alberta was from a specimen collected in 1912, from the Calgary area, though this has been considered a mislabeled specimen (Houston and McGowan 1999). The first live Barred Owl recorded in Alberta was one heard calling along the Athabasca River near Fort McMurray in 1934 (Preble 1941).

Dead Owls

Museum specimens, private collections, and dead owls turned in to Fish and Wildlife constituted 53 Barred Owl locations distributed throughout the province. The most southeasterly report was a dead owl turned in to Fish and Wildlife in February 1984 from Coronation (Boxall 1986). Morphological information collected on 26 owls shows that the majority were adults (24 of 26), 12 females, 10 males, 4 unknown sex. Boxall and Stepney (1982) reported an unusually high number of dead Barred Owls turned in to Fish and Wildlife during a short period of time (15 individuals from 1982 to 1985).

Banding, Literature and Personal Communications

Barred Owls have been banded on 38 occasions in Alberta from 1966 to 1999 (CWS Banding Office) by thirteen banders (Table 1). There were 15 clutches of owls banded at nest sites, as well as nine adult females, eight adult males, and three adults of unknown sex. Only one Barred Owl was banded before 1987 (2.6 percent).

There were 42 reports of Barred Owls collected from publications (Preble 1941; Jones 1956; Jones 1966; Salt and Wilk 1958; Salt and Salt 1976; Francis and Lumbis 1959; Jones 1987; Sadler and Myers 1976; Boxall and Stepney 1982; Rintout and Myers 1983; Pintel et al. 1991; Takats 1995) and 63 records collected from personal communications. Only 35 of these records were pre-1975 (33 percent). Jones (1987) summarized observations of Barred Owls as being "fairly evenly distributed in Alberta, particularly in Alberta's northern forests and heavily forested foothill regions of Alberta".

Holroyd and VanTighem (1983) report the Barred Owl as a rare, year-round resident in Banff and Jasper National Parks. They state:

> "It occurs regularly near Jasper townsite especially along the lower Miette River, where it has nested, and near Cottonwood Slough (Roy Richards, pers. comm.) and Pyramid Lake (R. Salt, pers. comm.). It has been recorded twice near North Saskatchewan River Crossing (M. Dyer, pers. comm.), twice near Vermilion Lakes Banff, once at Lake Annette (K. VanTighem, pers. comm.) and once near Maligne Canyon (J. Salt, pers. comm.)."

Volunteer Surveys

Breeding Bird Atlas volunteers reported 65 Barred Owl locations during a five-year survey from 1987 through 1991 (data were collected between February and July of each year). Atlas data showed that Barred Owls were concentrated in the Boreal Forest region,

TABLE 2. Barred Owl locations recorded on volunteer owl survey programs (EOP – Edmonton Owl Prowl, AOP – Alberta Owl Prowl, ANOS – Alberta Nocturnal Owl Survey).

Date	Location	Observation	Observer	
24 February 1988	Big Lake	1 individual	EOP –	Beck and Beck (1988)
5 March 1988	Cooking Lake	1 individual	EOP –	Beck and Beck (1988)
6 March 1988	Wabamun Creek	1 individual	EOP –	Beck and Beck (1988)
24 February 1989	Big Lake	1 individual	AOP –	E. Bamford
05 March 1989	Cooking Lake	1 individual	AOP –	R. and M. Berg
06 March 1989	Wabamun Lake	1 individual	AOP –	S. Jungkind, Belmonte, Gomez, Diener
21 May 1989	Water Valley	1 individual	AOP –	D. Hutchinson, D. Collister
10 April 1998	Lac La Biche	pair duetting	ANOS –	J. Gammon and P. Okrainec
15 May 1998	Shaw Lake	1 individual	ANOS –	J. Gammon
18 April 1998	Hillcrest Road	2 individuals	ANOS –	M. Heckbert and J. Doll
26 April 1998	Sibbald	1 individual	ANOS –	D. Woodsworth, Kanagawa, Mitchell
27 March 1999	Nojack South	1 individual	ANOS –	R. Gutsell, R. Wiacek, B. McCulloch

and primarily coniferous foothills and montane forests west of Calgary and in Jasper National Park (Semenchuk 1992). Few records indicated breeding evidence and only one possible breeding record was discovered, north of Lesser Slave Lake at La Crete along the Peace River. During Alberta Christmas Bird Counts from 1965 to 1998, volunteers in 44 count circles recorded 53 Barred Owls. Only 17 (32 percent) of these owls were recorded before 1990. Only four and two owls were recorded during Breeding Bird Surveys and May Species Counts, respectively.

There have been three volunteer surveys conducted specifically for owls (Table 2): Edmonton Owl Prowl (1988), Alberta Owl Prowl (1989), and the volunteer Alberta Nocturnal Owl Survey (1998 and ongoing). Seven Barred Owls were found during the first two owl surveys (Beck and Beck 1988, personal communication). Volunteer Alberta Nocturnal Owl surveyors found 13 individual Barred Owls (11 records) on eleven 10 km transects along roads (16 routes were surveyed throughout the province). The Alberta Bird Record contributed 35 more locations of Barred Owls in 1988 (Alberta Ornithological Records Committee).

Two intensive studies have been conducted on the Barred Owl in Alberta (Takats 1998; Olsen 1999). Takats (1998) conducted a study on distribution and abundance of the Barred Owl in the Foothills Model Forest (located in the foothills and mountains around Hinton and Jasper). Forty-two different territorial Barred Owls (10 females, 17 males, and 15 unknown sex) were recorded in 1995 and 1996. Of these, seven were paired and the other 28 were single but may have had mates that did not respond to broadcasts (Takats 1998). Surveys were continued in 1997 and 1998 and four additional Barred Owls were located. The density of Barred Owls was determined to be 0.05 and 0.04 owls/km^2, in 1995 and 1996, respectively.

The habitat used by Barred Owls at 45 calling locations in the Foothills Model Forest was predominantly older mixedwood forest containing Trembling Aspen (*Populus temuloides*), White Spruce (*Picea glauca*) and Balsam Poplar (*Populus balsamifera*). Roosting and foraging occurred in a variety of stand types, but were also predominantly older mixedwood *Populus* sp. and spruce (Takats 1998).

A study to evaluate the effects of forest fragmentation on bird communities was initiated in north-central Alberta (Schmiegelow and Hannon 1993). Preliminary work located six Barred Owl territories, and evidence of three breeding pairs was discovered in the Calling Lake area (G. Court, personal communication). Two additional territories and four additional breeding sites were found in a study from 1996 through 1998 (Olsen 1999). During the breeding season, the density of Barred Owls was 0.04 pairs/km^2. Owls were found to use old growth mixed forest stands (Olsen 1996).

Breeding Records

There were 54 breeding records (only three found before 1975). The first evidence of breeding was recorded in 1949 (Grant 1966), but the first nest was not discovered until 1966, in Edmonton (Jones 1966) (Table 3). Boxall and Stepney (1982) reported eight breeding records, and Semenchuk (1992) reported six confirmed breeding records during the Provincial Breeding Bird Atlas Project (1987-1991). The northern-most breeding record was a nest found at 58° 19' latitude and 116° 17' longitude near La Crete (Takats 1995). Some local residents have reported Barred Owls to be present for over 20 years.

Breeding records for Barred Owls were not common (n = 54) and only 46 nests have been found (1966 through 1999): 38 (82.6 percent) were in natural cavities (or bowls on top of dead trees that had broken off), two (4.3 percent) were in stick nests, one (2.2 percent) was in a man-made stick nest, and five (10.9 percent) were in nest boxes. In most cases owls nested in older mixedwood stands and used large diameter *Populus* sp. trees (> 40 cm) (primarily Balsam Poplar) for

TABLE 3: Confirmed breeding records of Barred Owls for Alberta.

Date	Location	Nest Type	Observer/Reference
1949	Lesser Slave Lake	Unknown	Grant (1966)
1966	Edmonton	Cavity Nest	Jones (1966)
1968*	Edmonton	Cavity Nest	E. Jones (personal communication)
1976*	Blue Lake	Cavity Nest	Boxall and Stepney (1982)
1977*	Jasper	Cavity Nest	Boxall and Stepney (1982)
1977*	Blue Lake	Cavity Nest	Boxall and Stepney (1982)
1978	Chilver Lake	Unknown	Wiseley (personal communication)
1979*	Miette River	Cavity Nest	Richards (personal communication)
1980*	Miette River	Cavity Nest	Richards (personal communication)
1984**	Spruce Grove	Cavity Nest	R. Copeland (personal communication)
1988	Deerland	Cavity Nest	R. Cromie (Nest Card)
1989	Deerland	Cavity Nest	R. Cromie (Nest Card)
1990	Deerland	Cavity Nest	R. Cromie (Nest Card)
1991	Deerland	Cavity Nest	R. Cromie (personal communication)
1991	Niton	Cavity Nest	H. Pletz/B. Gehlert
1992	Deerland	Cavity Nest	R. Cromie (Nest Card)
1993	La Crete	Cavity Nest	Takats (1995)
1994	La Crete	Cavity Nest	Takats (1995)
1994	Millarville	Unknown	D. Collister (personal communication)
1994	Uncas	Man-Made Platform	R. Cromie (Nest Card)
1994	Tawatinaw	Cavity Nest	R. Cromie (Nest Card)
1994	Elk Island	Stick Nest	H. Pletz (personal communication)
1994	Calling Lake	Unknown	G. Court (personal communication)
1994	Miette River	Cavity Nest	Takats (1998)
1995	Lynx Creek	Cavity Nest	Takats (1998)
1995	Miette River	Cavity Nest	Takats (1998)
1995	La Crete	Cavity Nest	A. Miller (personal communication)
1995	Tawatinaw	Cavity Nest	R. Cromie (Nest Card)
1995	Cross Lake	Cavity Nest	R. Cromie (Nest Card)
1995	Uncas	Nest Box	R. Cromie (Nest Card)
1995	Calling Lake	Cavity Nest	G. Court (personal communication)
1995	Calling Lake 2	Cavity Nest	G. Court (personal communication)
1996	Bragg Creek	Cavity Nest	H. Pletz (personal communication)
1996	Solomon Creek	Cavity Nest	Takats (1998)
1996	Blackcat Ranch	Cavity Nest	Takats (1998)
1996	Miette River	Cavity Nest	Takats (1998)
1996	Tawatinaw	Nest Box	R. Cromie (Nest Card)
1996	Calling Lake	Unknown	Olsen (1999)
1997	Cross Lake	Cavity Nest	A. Karvonen (personal communication)
1997	Miette River	Cavity Nest	L. Takats (personal communication)
1997	Tawatinaw	Cavity Nest	R. Cromie (Nest Card)
1997	Lac La Biche	Stick Nest	Olsen (1999)
1997	Calling Lake	Cavity Nest	Olsen (1999)
1998	Uncas	Cavity Nest	R. Cromie (personal communication)
1998	Solomon Creek	Cavity Nest	L. Takats (personal communication)
1998	Calling River	Cavity Nest	T. Roper (Nest Card)
1998	Calling Lake	Cavity Nest	Olsen/Cromie (Nest Card)
1999	Uncas	Nest Box	R. Cromie (Nest Card)
1999	Tawatinaw	Nest Box	R. Cromie (Nest Card)
1999***	Vinca	Cavity Nest	H. Pletz (Nest Card)
1999	Cross Lake	Nest Box	R. Cromie (Nest Card)

* Boxall and Stepney (1982) ** Nest cut down, two eggs cracked, one survived, owl held at Valley Zoo, Edmonton
*** One young Barred Owl was fostered in to this nest.

nesting (Takats 1998; Avian Raptor Nest Cards; Olsen 1999). Nest boxes built specifically for Barred Owls were readily taken over in areas where natural cavities were not abundant (G. Court, personal communication; R. Cromie, personal communication).

Distribution

Most occurrences of Barred Owls were in the boreal forest, foothill, and mountain ecoregions from 1912 through 1974 (Figure 2) and from 1975 to the present (Figure 3). Few owls were recorded in the parkland,

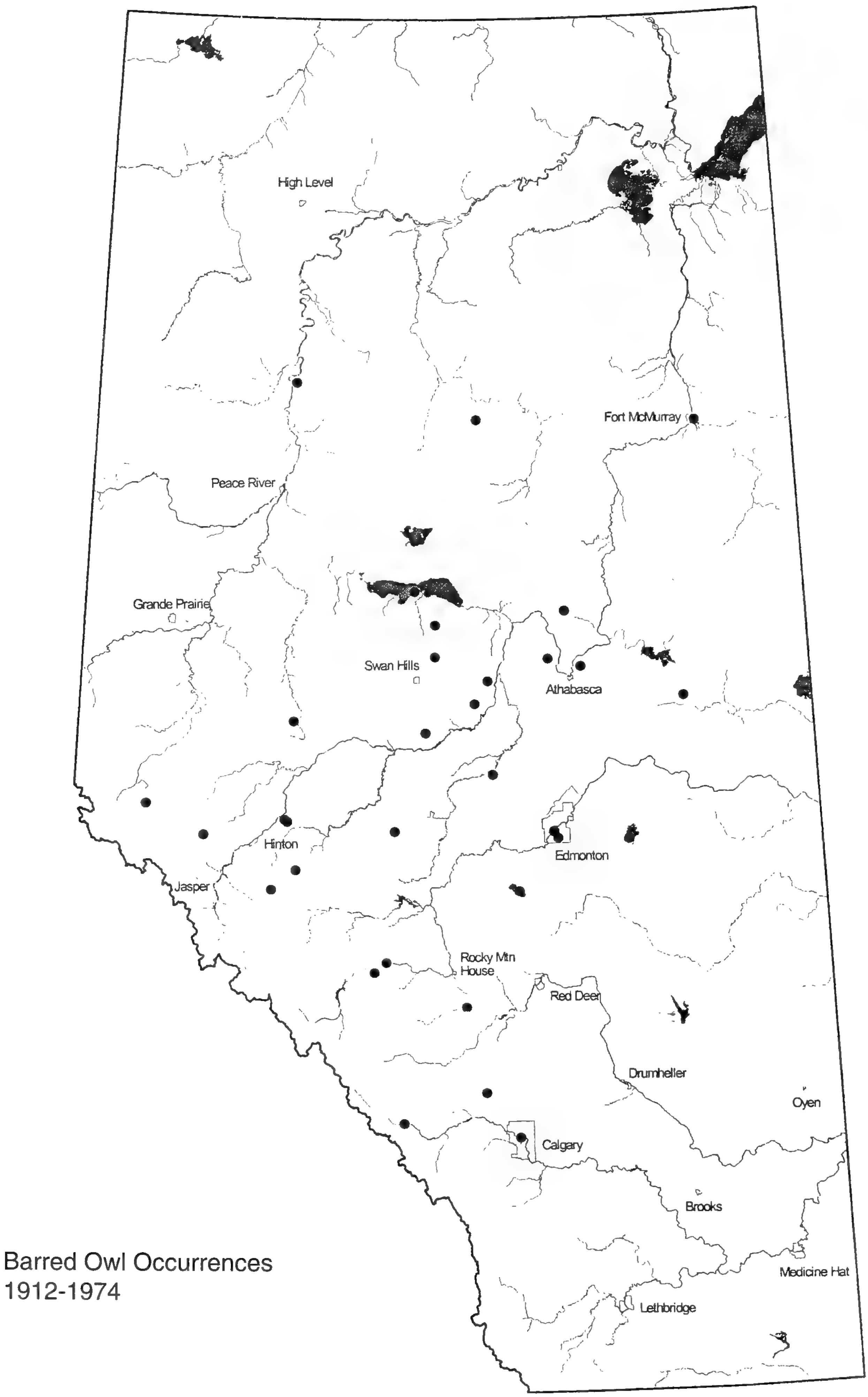

FIGURE 2. Barred Owl distribution from 1912 through 1974 (map courtesy of Alberta Conservation Association/Alberta Sustainable Resource Development).

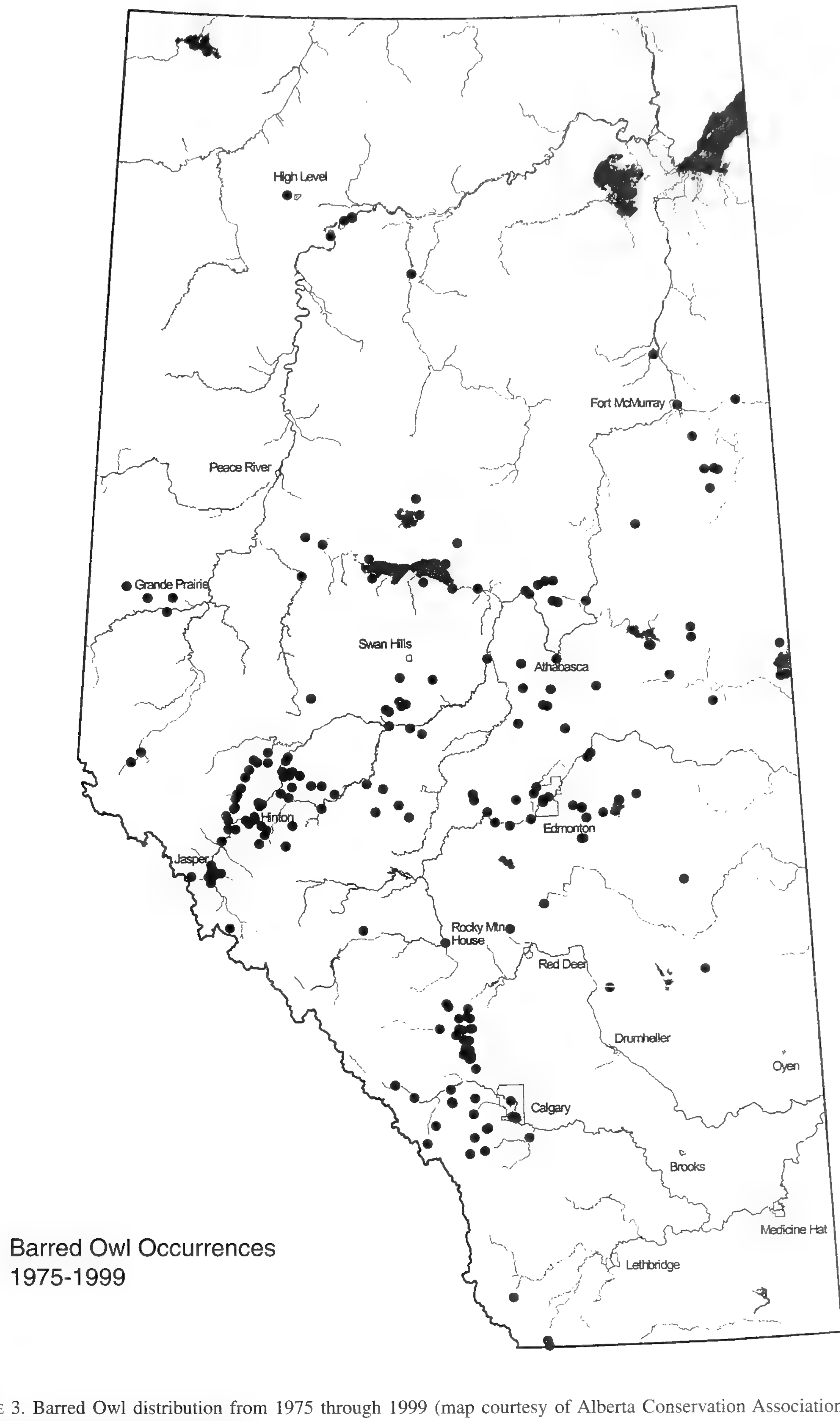

FIGURE 3. Barred Owl distribution from 1975 through 1999 (map courtesy of Alberta Conservation Association/ Alberta Sustainable Resource Development).

and only one individual was recorded in the northern limit of the grassland ecoregion. Detection of Barred Owls appears to have increased after 1975, but there have been only two records outside the range of the early distribution map.

Discussion

The Barred Owl is distributed over much of Alberta's forested area. Evidence suggests that Barred Owl distribution in the province has changed little over the last 100 years. As more detailed studies are conducted, as there is an increase in the number of interested naturalists exploring isolated woodlands, and as there is increased access to remote areas, more reports of Barred Owls will accumulate, Oeming (1957) and Jones (1966) concur. Mazur et al. (2000) suggested that Barred Owls are shy of humans, which may account for their secretive nature.

In British Columbia the first records of Barred Owls were from Liard Crossing in 1943 and Nechako Lowlands in 1946 (Campbell et al. 1990). Scotter et al. (1985) reported a Barred Owl record from 1977 in the South Nahanni River, Northwest Territories, which shows that Barred Owls have existed northwest of Alberta for over 20 years. As well, the idea that the Barred Owl is adapting to the coniferous boreal forest does not hold true. Barred Owls have shown a clumped distribution in areas that contain large deciduous trees (predominantly riparian areas). They use Balsam Poplars for nesting and rely on a more open subcanopy for flight, although the roost cover provided by White Spruce trees is important, particularly in the winter (Takats 1998). Some of the first records of Barred Owls occurred along riparian areas.

The Sensitive designation assigned by Alberta Sustainable Resource Development (2000) is well founded. Based on recent studies and personal communications with raptor banders and naturalists, the Barred Owl should not be considered rare in Alberta; however, this species does have a clumped breeding distribution. As well, these owls rely on cavities in old, large diameter *Populus* sp. trees for nesting, and select old and/or mature mixedwood forests (a habitat that is in decline) to fulfill their life requisites (Takats 1998; Olsen et al. 1996*; Olsen 1999; Mazur and James 2000).

As older forests are usually targeted first for harvest, the amount of old growth forest remaining decreases and stands become increasingly fragmented. Loss of nesting, roosting, and foraging habitat occurs when a forest is clearcut; moreover, Great Horned Owls, *Bubo virginianus*, are known to favour fragmented landscapes. There is direct conflict between these two owl species, with the Barred Owl losing out to the larger Great Horned Owl (Bent 1961; Bosakowski 1994; Laidig and Dobkin 1995; Takats 1998 and field notes; Olsen 1999; G. Court, personal communication). Barred Owl numbers and range are limited by the amount of adequate nesting habitat available where they can reproduce successfully and fledge their young without interference from competitors and predators.

Acknowledgments

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Use of Eelgrass, *Zostera marina*, Wrack by Three Species of Ladybird Beetles (Coleoptera: Coccinellidae) in Prince Edward Island

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Garbary, David J., Sarah Fraser, Carrie Ferguson, Randolph F. Lauff. 2004. Use of Eelgrass, *Zostera marina*, wrack by three species of ladybird beetles (Coleoptera: Coccinellidae) in Prince Edward Island. Canadian Field-Naturalist 118(2): 225-228.

Large numbers of the introduced ladybird beetle, *Coccinella septempunctata* L., were present at Wood Islands and Green Point, Prince Edward Island, in wrack consisting primarily of *Zostera marina* L. (Eelgrass). The wrack occurred in a 0.5 to 1.0 m band parallel to the shore, and was from five to 25 cm thick. The other ladybirds, *Propylea quatuordecimpunctata* (L.), an introduced coccinellid also found in high numbers, and an individual of the native *Hippodamia tredecimpunctata* (Say) were found only at Wood Islands. At both sites the ladybird beetles occurred in the mid-intertidal zone along at least 100 m of shoreline, and were absent to rare on the terrestrial vegetation above the high tide mark. At four of the other eight sites surveyed, occasional individuals were present in the wrack, but they were no more abundant than could be observed on landward vegetation. Mean densities of C. *septempunctata* at the two primary sites were 52 m^{-2} (Green Point) and 410 m^{-2} (Wood Islands).

Key Words: *Coccinella septempunctata, Propylea quatuordecimpunctata, Hippodamia tredecimpunctata,* ladybird beetles, Coccinellidae, *Zostera marina,* Eelgrass, intertidal zone, Prince Edward Island.

With over 150 species and subspecies, the Coccinellidae of Canada and Alaska are a conspicuous and ecologically important element of the terrestrial biota (McNamara 1991). In addition to the native fauna, there is great interest in the distribution of invasive ladybirds and the subsequent loss of native biodiversity (Gordon and Vandenberg 1991). This is also true in eastern Canada where Hoebeke and Wheeler (1996) and McCorquodale (1998) and Majka and McCorquodale (in press) reported the spread of introduced species in the Maritimes.

Despite being a terrestrial family, there are several reports of Coccinellidae from beaches and salt marshes in both freshwater and marine environments (Davis and Gray 1966; Schaefer et al. 1987; Turnock 1996; Pupedis 1997; review by Nalepa et al. 1998). Here we report on the mass occurrence of living ladybird beetles in the marine intertidal of Prince Edward Island and their association with Eelgrass *(Zostera marina)* wrack.

Materials and Methods

Ten intertidal locations on Prince Edward Island (Table 1) were visited on 30-31 August 2002 for the examination of Eelgrass wrack as part of a study on Eelgrass decline. An abundant population of ladybird beetles was at site one (Wood Islands), and several hours were spent photographing and quantifying the assemblage. At subsequent sites three individuals inspected the wrack for a minimum of 15 min along at least 100 m of shoreline. If only a few beetles were observed, their presence was noted. If many were present, densities were calculated using a 20 × 20 cm quadrat. The quadrat was placed haphazardly on the eelgrass wrack (n = 25) at irregular intervals on the shore.

Characteristics of the primary study sites were: The Wood Islands site was a sandy beach with sandstone outcrops. The primary species of seaweeds associated with the wrack were recorded. Green Point was a salt marsh adjacent to an abandoned wharf, and common plants in the marsh were recorded. At Green Point the wrack was almost exclusively Eelgrass. Characteristics of other sites are mentioned, where necessary, in the body of the text. The weather on both days was mostly bright and sunny; however, a mild rain fell at Marchwater (1800 h, 30 August) and Belmont Provincial Park was extremely windy (0800 h, 31 August). Coordinates of primary sites were determined using a global positioning system (Garmin GPS 12, Olanthe, Kansas; Table 1).

Beetles were identified using the keys in Gordon (1985) and by comparison with specimens in the insect collection at St. Francis Xavier University. Voucher specimens have been deposited in the Herbarium of St. Francis Xavier University (STFX) and in the insect collection.

Results

Three species of ladybird beetles, *Coccinella septempunctata, Hippodamia tredecimpunctata,* and *Propylea quatuordecimpunctata,* were present in intertidal Eelgrass wrack *(Zostera marina)* in Prince Edward Island during late August. All species were present at Wood Island; however, only *C. septempunctata* was collected from the other sites.

TABLE 1. Relative abundance of P. *quatuordecimpunctata, H. tredecimpunctata* and *C. septempunctata* in sites across Prince Edward Island, and their corresponding GPS coordinates. "Low" corresponds with an observation of < 5 individuals.

Site	Coordinates	Abundance
Wood Islands	45°56'N 62°45'W	Very high
St. Peters Bay	46°26'N 62°28'W	Absent
March Water	46°29'N 63°44'W	Absent
Belmont Provincial Park	46°31'N 63°49'W	Absent
Green Point	46°35'N 63°52'W	High
Cascumpec Bay	46°45'N 64°04'W	Absent
Linkletter Provincial Park	46°24'N 63°51'W	Low
Victoria Provincial Park	46°12'N 63°30'W	Low
West River Bridge	46°11'N 63°14'W	Low
Pinnette Provincial Park	46°04'N 62°54'W	Low

At Wood Islands, *C. septempunctata* occurred primarily in a loose to dense band of Eelgrass wrack, 0.2-1.0 m wide, that formed in the mid-intertidal zone on a sandy beach (Figure 1). No coccinellid beetles were found in the dry wrack in the splash zone nor in the mixed herbaceous vegetation above the high tide mark. A few beetles were also found in small clumps of wrack lower in the intertidal zone that had recently been inundated by the incoming tide and very gentle wave action. The wrack consisted mostly of leaves of Eelgrass and was mixed with several common seaweeds including the brown algae, *Fucus serratus, Chorda filum, Chordaria flagelliformis,* and the red algae, *Chondrus crispus* (Irish moss), *Palmaria palmata* (Dulse) and *Furcellaria lumbricalis.* The Eelgrass was relatively fresh and had numerous green leaves.

The beetles were present on the exposed wrack to about two cm into the wrack mass in loosely packed leaves (Figure 2). Beetle density was 410 ± 340 m^{-2} (mean ± SD). Beetles were absent deep within the 20-30 cm thick wrack bundles. The beetles walked along the surface of the leaves and were single or in clumps of two-five individuals. Occasional beetles were present on the bare sand adjacent to the wrack or on clumps of seaweed (mostly *Chorda filum* and *Fucus serratus)* that separated from the main body of wrack. No flying beetles were observed; however, walking beetles occasionally spread their elytra.

At Green Point, the Eelgrass wrack accumulated in a 0.5 – 2 m band in the mid-intertidal zone of a salt marsh. This was a typical marsh dominated by *Spartina alterniflora* in the lower marsh and a mixture of *S. patens, Scirpus americanus, S. maritimus, Glaux maritimus, Triglochin maritima* and *Limonium nashii* in the mid-intertidal zone. At various sites along the shore there was extensive accumulation of old Eelgrass in the upper intertidal zone. The Eelgrass wrack tended to form a blanket that matted down the surrounding vegetation or occasionally was suspended up to 30 cm above the ground.

The beetles (all *C. septempunctata)* were found on the Eelgrass in the mid-intertidal zone, with rare individuals on the surrounding grasses and sedges. The insects were common (52 ± 8.5 m^{-2}) over more than 100 m of shoreline, and were typically single. Beetles were absent on the upper intertidal wrack, and none were observed in the lower intertidal zone. The insects walked on the Eelgrass and did not fly. In addition to the ladybird beetles, one *Leptinotarsa decemlineata* (Colorado Potato Beetle) was observed on the wrack.

At Linkletter and Pinnette Provincial Parks and West River Bridge, 3-5 beetles (all C. *septempunctata)* were found on Eelgrass in the upper intertidal zone. These sites were primarily sand beaches with either scattered clumps or continuous carpets of Eelgrass up to 2 m wide in the high intertidal zone. At St. Peters Bay, Belmont and Victoria Provincial Parks and Cascumpec Bay, beetles were absent, despite the presence of extensive Eelgrass wrack.

Upon our return to Wood Islands, 28 h after the initial observations, we found that the previous day's wrack had largely disappeared. A few hundred dead ladybird beetles were present in the remaining wrack and on sandstone outcrops along with a few live individuals.

FIGURE 1. Ladybird beetle site at Wood Islands, Prince Edward Island, showing band of intertidal wrack on beach with investigator (C.F.) examining Eelgrass.

Discussion

Although the records for both introduced species (*C. septempunctata, P. quatuordecimpunctata*) do not represent range extensions, it is disturbing that they did make up essentially all of the coccinellid fauna at the sampled sites. *P. quatuordecimpunctata* has been recorded in PEI since at least 1994 (Hoebeke and Wheeler 1996). The first records for C. *septempunctata* on PEI (Charlottetown) are from 1982; it is now abundant in the province (Majka and McCorquodale; in press). The two sites where *C. septempunctata* was abundant shared the feature of having abundant Eelgrass wrack in the mid-intertidal zone. The beetles were generally not found in the older, dry wrack at the upper part of the shore nor in the vegetation above the high tide mark (Wood Islands and Green Point), and the surrounding salt marsh vegetation (Green Point). Examination of the Eelgrass substratum showed no conspicuous populations of invertebrates that might be a suitable food source. In addition, the beetles were sluggish, suggesting exhaustion due to struggling or partial suffocation. The location of the beetles and their behaviour suggest that the they were only recently washed up to the eelgrass wrack, a substrate which allowed them firm footing. Sites with few or no beetles had less fresh Eelgrass wrack. The intertidal substratum at these sites tended to be rockier, with better developed populations of seaweed.

Although terrestrial, both C. *septempunctata* and *Propylea quatuordecimpunctata* have previously been found in coastal habitats including salt marshes in Connecticut, North Carolina and Delaware (Schaefer et al. 1987; Pupedis 1997; Nalepa et al. 1998). Davis and Gray (1966) also reported another ladybird beetle, *Naemia serriata,* from a salt marsh in North Carolina. The mass occurrences of C. *septempunctata* that we found are different from that in Delaware in which numerous dead and some living individuals were washed ashore following deposition in the ocean and association with seaweed wrack (Schaefer et al.

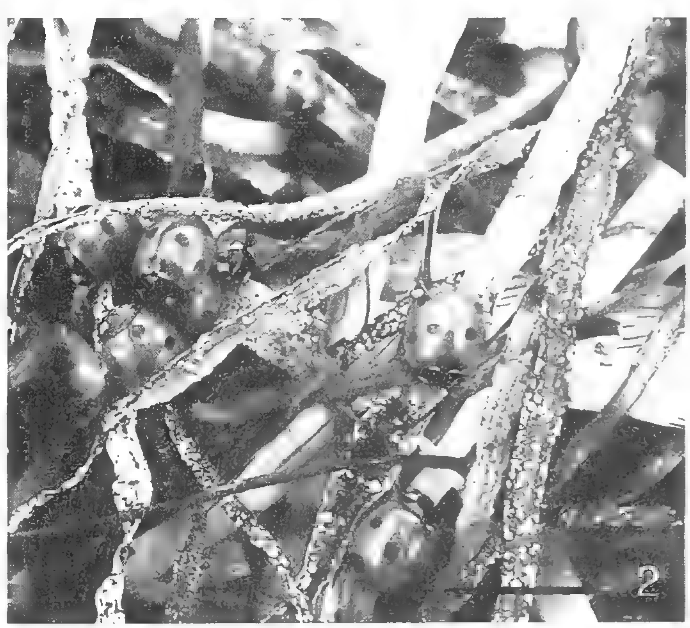

FIGURE 2. *Coccinella septempunctata* on mid-intertidal Eelgrass wrack. Note: The white spots on the leaves are a calcified red alga.

1987). The North Carolina mass occurrence is similar to that reported by Schaefer et al., and involved mass mortality and shore deposition (Nalepa et al. 1998). Turnock (1996) suggested that accumulations of lady beetles on the shores of Lake Manitoba resulted from wave deposition and subsequent migration up the shore to structures protruding from the sand. Given the localization of C. *septempunctata* in this study, particularly at Green Point, the Eelgrass seems to have been a fortunate substratum on which the beetles could take hold, and rest prior to dispersal.

Although there were conspicuous corpses of ladybugs in the wrack at Wood Islands on the day after the survey, the vast majority of the population had disappeared from the shore. There was no evidence that the beetles had moved onto the grassy field adjacent to the beach. Invasions of Coccinellidae into North America show that these species can cover a large distance (Schaefer et al. 1987). McCorquodale (1998) gives range expansion rates of 31-440 km y^{-1} across North America for four introduced coccinellids in Nova Scotia, although he concedes that not all of this is likely to be long distance flights. Schaefer et al. (1987) comment on the occurrence of C. *septempunctata* on Sable Island, 300 km from mainland Nova Scotia. Thus the 20 km flight across the Northumberland Strait to or from Nova Scotia is reasonable, especially if a suitable wind is available.

Our records of *C. septempunctata* on the north and south shores of PEI are consistent with eelgrass providing a staging substratum during migration. Migrations of *Hippodamia convergens* cover hundreds of kilometres in single flights in California from San Francisco and the Imperial Valley to the Sierra Nevadas (Hodek 1973). However, the aggregations we observed in Prince Edward Island are more likely reflective of accidental downing of migrating populations as a result of weather conditions, followed by subsequent wash-up. The Eelgrass provided a better refugium than other substrata in the mid-intertidal zone. We suggest that the beetles are only saved by the Eelgrass wrack, and that there is no particular attraction to it as previously described for similar vegetation with *C. septempunctata* (Schaller and Nentwig 2000; Frantsevich and Zolotov 2001).

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Predicting the Effects of Cerulean Warbler, *Dendroica cerulea* Management on Eastern Ontario Bird Species

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Jones, Jason, William J. McLeish, and Raleigh J. Robertson. 2004. Predicting the effects of Cerulean Warbler, *Dendroica cerulea,* management on eastern Ontario bird species. Canadian Field-Naturalist 118(2): 229-234.

Single-species habitat management strategies are often undertaken without explicit consideration of their effects on the larger community. Here we explore the potential effects of managing eastern Ontario deciduous forests for the Cerulean Warbler (*Dendroica cerulea*) by examining its potential as a biodiversity indicator species and as an umbrella species. Our results indicate that the Cerulean Warbler would not be an effective biodiversity indicator, as its distribution across the studied landscape did not coincide with areas of high avian species richness. However, the Cerulean Warbler may be effective as an umbrella species for the maintenance of populations of other canopy-nesting species that require mature deciduous forest habitats. It is hoped that the conclusions reached in Ontario, while perhaps not directly transferable to all parts of the breeding range, encourage other Cerulean Warbler researchers to ask similar questions in their study areas.

Key Words: Cerulean Warbler, *Dendroica cerulea,* conservation utility, biodiversity indicator species, umbrella species, eastern Ontario.

Few North American songbirds are receiving the scientific and conservation attention that is currently focused on the Cerulean Warbler (*Dendroica cerulea*; Robbins et al. 1992; Rosenberg et al. 2002*; Hamel et al. 2004). The Cerulean Warbler has suffered significant long-term breeding population declines (annual declines of 3.04% over 1966-2000; Link and Sauer 2002) which are largely attributed to habitat destruction on both the breeding and wintering grounds (Robbins et al. 1992). Concern over the long-term health of this species has led to its designation as threatened, rare, or of special concern in the United States and as a Species of Special Concern in Canada (Robbins et al. 1992; Hamel 2000; COSEWIC 2003*).

In two separate meeting in 2001 and 2002, a group of academic and governmental scientists, land managers, industry biologists and non-governmental organizations formed the Cerulean Warbler Technical Group (CWTG): an effort to develop a proactive, broad-based, multiple stakeholder approach to Cerulean Warbler conservation in both North and Latin America (Hamel et al. 2004). One of the outcomes of these meetings was a breeding grounds research plan that is designed to identify key population limitation factors and explore forest management options for the maintenance and creation of Cerulean Warbler habitat on a range-wide basis.

Ironically, the very thing that limits our ability to currently diagnose specific reasons for breeding ground population declines – a general lack of natural and life-history information – may also limit the efficacy of the CWTG research plan. Here, we take advantage of data collected during one of the longest running Cerulean Warbler research programs in North America (dating to 1994; Oliarnyk and Robertson 1996; Jones et al. 2000, 2001, 2004; Jones and Robertson 2001; Barg et al. 2005) to make predictions regarding the potential effects of managing deciduous forests for Cerulean Warblers on sympatric bird species in eastern Ontario. Specifically, we ask two questions. One, will the promotion of Cerulean Warblers and Cerulean Warbler habitat promote the preservation of avian diversity? In other words, is the Cerulean Warbler a biodiversity indicator (*sensu* Landres et al. 1988)? Two, can the Cerulean Warbler act as an umbrella species for other bird species with similar life – and natural histories? The protection of the habitat of the umbrella species ideally results in the protection of the habitat of those species whose requirements are subsumed by those of the umbrella (Launer and Murphy 1994; Berger 1997; Simberloff 1998).

Study Area and Methods

This investigation was conducted at the Queen's University Biological Station (QUBS), Ontario (44°34'N, 76°20'W), within the Great Lakes-St. Lawrence mixed forest region. Our study area was restricted to approximately 2 600 ha of research tracts managed by QUBS. The landscape in the area is dominated by mature, secondary-growth, lowland mixed deciduous forest, interspersed with rocky outcrops, marshes, lakes and abandoned agricultural fields.

Bird surveys. In 1997 and 1998, we surveyed birds on QUBS property using variable-circular-plot point counts (Reynolds et al. 1980; Jones et al. 2000). We surveyed 80 stations in 1997 (17 May – 20 June) and 67 stations in 1998 (21 May – 21 June); the 1998 stations were a subset of those sampled in 1997. The point-count stations were located to maximize spatial coverage of the study area. Each point count was 10 min long. Each station was separated by at least 200 m to minimize the potential for double-counting individuals. Point counts were conducted between 0.5 hr before sunrise and 3 hr after sunrise EST in order to sample during peak song activity, and were only conducted under calm weather conditions. For our analyses we included birds detected within 100 m of the plot center. Probability of detection was similar for all species analysed, as the detection thresholds for all but one species (Black-and-white Warbler, *Mniotilta varia*, 92 m) were beyond 100 m (Jones unpublished data). Data from the first two visits per station each year were used in the analyses to facilitate comparison between years and because two visits are sufficient to confirm the presence or absence of Cerulean Warblers (Jones et al. 2000).

Vegetation Surveys. We collected vegetation data at 59 point-count stations in 1997 at five circular subplots, each with a radius of 5 m. The first subplot was centered on the point count station center and the other four were located 50 m away in each of the cardinal directions. Within each of the subplots we counted the number of saplings [stems < 3.0 cm diameter at breast height (dbh)], measured the dbh of all stems ≥ 3.0 cm and grouped them into two size classes (3.0 – 15.0 cm dbh, 15.0 – 30.0 cm dbh). Using an imaginary 1 m radius cylinder projected upward from the forest floor, we estimated cover within 3 m height intervals from the ground to the top of the canopy. Total cover and percent cover of each woody plant species was estimated by eye in each height interval on a scale of 0 to 10 (0 = 0% cover, 10 = 100% cover). Two observers made all cover estimates; the two observers spent several days prior to data collection assuring that their cover estimates were within 10% of one another. For analysis we reduced these cover estimates to two variables: maximum cover below 6 m (understory cover) and maximum cover above 12 m (canopy cover). Each vegetation variable was averaged across subplots to describe the habitat of the point-count station. We measured only those vegetation variables thought to be important to Cerulean Warblers; the importance of these variables has been supported by subsequent research (Jones and Robertson 2001; Jones et al. 2001). We also restricted the number of vegetation variables for analytical reasons (see below).

Data Analysis. In our analyses, we included only those species known to breed in our study area. We also excluded species that are not adequately sampled by diurnal point counts, such as colonial nesters (e.g., Barn Swallow, Hirundo rustica), nocturnal species (e.g., Whip-poor-will, Caprimulgus vociferus), waterfowl (e.g., Wood Duck, Aix sponsa), and waders (e.g., Great Blue Heron, Ardea herodias).

(1) Biodiversity indicator evaluation

We tested whether the presence of Cerulean Warblers was a predictor of overall bird species richness. For the purposes of these analyses, we defined species richness as the number of species detected in the first two visits to a point-count station, excluding the Cerulean Warbler if present. We used randomization tests to compare the mean species richness at stations where Cerulean Warblers were present to the expected species richness at a randomly generated sample of points (Chase et al. 2000). In these tests, the mean species richness was calculated for a random sample of point-count stations, with the number of random stations equaling the number of stations where Cerulean Warblers were detected in a given year. We iterated this procedure 1000 times to generate an expected distribution of mean species-richness values. We then compared the observed species richness associated with Cerulean Warblers and determined its statistical significance. These randomization tests were performed using S-PLUS 4.0 (Mathsoft 1997*). Values reported in the results are means ± SE.

(2) Umbrella species evaluation

The initial step in evaluating the potential of the Cerulean Warbler as an umbrella species was to establish an ecological context. We categorized the bird species detected during our surveys into species groups based on habitat preferences, diet and foraging substrate, and nesting substrate. These classifications were based on observations reported in the literature (Ehrlich et al. 1988; Robbins et al. 1989a; Freemark and Collins 1992; Canterbury et al. 2000); we did not include our survey data in these classifications. In addition, we created a conservation concern grouping that included species which were experiencing statistically significant population declines as indexed by North American Breeding Bird Survey data for 1966-2000 (Sauer et al. 2001*). For the purposes of these analyses we focused on the groups to which Cerulean Warblers belonged: mature forest habitat (n = 13 species), insect-foliage foragers (n = 15), canopy nesters (n = 12), and species of concern (n = 14).

We used two methods to test if the distribution of Cerulean Warblers was representative of the distributions of other species in the same functional group. First, we used the checkerboard score (*C*-score) developed by Stone and Roberts (1990) to test for non-randomness in presence-absence matrices. One of the reasons we selected this metric of co-occurrence is that is not particularly prone to Type 1 error (Gotelli and Entsminger 2000*) and, unlike other co-occurrence metrics, it allows for overlap in species distributions (Gotelli and McCabe 2002; Feeley 2003). We calculated *C*-scores (hereafter, observed *C*-score) for each

TABLE 1. Interpretation of the principal components axes from analysis of 5 vegetation variables for 59 point-count stations. Bold-face eigenvalues significant following bootstrap analyses.

Axis	CV[a]	CC[b]	UC[c]	SPD[d]	SSD[e]	LSD[f]	Interpretation of positive axis values
PC1	29.2	**0.6249**	**-0.6281**	-0.2509	0.0187	0.3195	mature forest with dense canopy
PC2	54.1	0.2676	0.2143	**0.7024**	0.5205	0.3438	mid-succession forest
PC3	74.2	0.0036	0.3208	0.1185	**-0.7046**	**0.6218**	mid- to late-succession forest
PC4	88.5	**-0.4737**	0.0870	-0.4715	0.4648	**0.5742**	mature forest with patchy canopy
PC5	100.0	0.5599	**0.6702**	-0.4553	0.1280	-0.1171	early succession forest

[a]Cumulative variance explained; [b]Canopy cover (% cover > 12.0 m); [c]Understory cover (% cover < 6.0 m); [d]Sapling density (stems/m^2); [e]Stem density (stems/m^2) 3.0-15.0 cm dbh; [f]Stem density 15.0-30.0 cm dbh.

functional group to examine if species within each functional group were distributed randomly across the landscape with respect to one another. For each survey year, we used re-sampling techniques to calculate 10 000 *C*-scores based on the original presence-absence matrix. The observed *C*-score was then compared with the generated distribution of expected *C*-scores. A *C*-score significantly greater than expected indicates that the assemblage is competitively structured; that is, individual species have distinct, and often exclusive, distributions (Stone and Roberts 1990). Conversely, a *C*-score significantly smaller that expected indicates that there is a degree of cohesion in the distribution patterns of the species included in the matrix. All *C*-score calculations were carried out using EcoSim 5.0 (Gotelli and Entsminger 2000). For all iterations, the number of species detected at each point-count station was kept consistent with the original matrix and each station was equally likely to be inhabited by a given species. Survey results from 1997 and 1998 were analyzed separately.

In our second test, we used logistic regression analyses to predict the probability of occurrence along a habitat gradient for all species within each species group to which Cerulean Warblers belonged. The Red-eyed Vireo (*Vireo olivaceus*) was not included in these analyses due to its near-ubiquitous distribution. For these analyses we included only the 1997 surveys of the 59 point-count stations for which we collected vegetation data. We generated the habitat gradient by entering all five vegetation variables into a principal components analysis, giving us an approximate 10:1 ratio of sites to variables. We tested the significance of the eigenvalues for each variable within each component using a bootstrap approach, following the recommendations of Peres-Neto et al. (2003). We drew 1000 bootstrap samples by resampling entire rows with replacement, thereby ensuring that the bootstrap matrices had the same dimensions as the original vegetation matrix; we conducted a PCA on each of these 1000 matrices. *P*-values were estimated by the number of bootstrap loadings equal to or less than zero for original loadings that were positive (greater than or equal to zero for negative loadings), divided by 1000. For the purposes of this paper, we considered $P = 0.10$ as our significance cut-off. The first PC axis (PC1) explained 29% of the variance of the vegetation data (Table 1); positive values along PC1 represented sites of mature deciduous forest and negative values represented early successional forest. We included PC1 as the independent variable in our logistic regression analyses. All these analyses were performed with JMP IN 4.0.2 (SAS Institute Inc. 2000*) and MS-EXCEL using the PopTools add-in module (Hood 2002). We calculated 95% confidence intervals around the logistic regression coefficient to facilitate comparison of occurrence probabilities across species.

Results

(1) Biodiversity indicator – The presence of Cerulean Warblers was not a significant predictor of avian species richness in either 1997 or 1998. In other words, observed species richness at Cerulean Warbler point-count stations was not significantly different from species richness expected by chance, based on bootstrap analyses (1997, observed richness 12.69 ± 0.75 species, expected 13.95 ± 0.03, $P = 0.12$; 1998, observed 9.75 ± 0.63, expected 9.82 ± 0.03, $P = 0.83$).

(2) Umbrella species – All three of the species groups to which Cerulean Warblers belong exhibited cohesive distributions in both 1997 and 1998, as indexed by their *C*-scores (Table 2). *C*-scores that are significantly lower then expected are indicative of co-occurrence in the distribution patterns of the species included in the analyses. Species of conservation concern also exhibited cohesive distributions in both 1997 and 1998 (Table 2).

The results of the logistic regression analyses using PC1 indicate that species within each of the species groups to which Cerulean Warblers belonged were distributed differentially along the generated habitat gradient, some more so than others (Table 3). Within the mature forest group, only one of the 12 group species (Black-and-white Warbler) did not overlap with the Cerulean Warbler confidence intervals. Similarly, only one of the 12 canopy nesting species (Blue Jay, *Cyanocitta cristata*) did not overlap with the Cerulean Warbler confidence intervals. Conversely, the insect-

TABLE 2. Tests for cohesive distributions of functional groups, as indexed by the *C*-score of Stone and Roberts (1990). Estimated values are mean ± SE for a generated random distribution based on the actual presence-absence matrix for each group for each year. *C*-scores that are significantly lower then expected are indicative of co-occurrence in the distribution patterns of the species included in the analyses.

	1997			1998		
Functional Group	Observed	Expected	*P*	Observed	Expected	*P*
Mature forest	80.76	91.94 ± 0.03	0.0003	41.42	48.13 ± 0.02	0.0017
Insect-foliage	86.02	92.29 ± 0.02	0.0050	52.96	65.15 ± 0.02	<0.0001
Canopy nesters	67.03	71.92 ± 0.02	0.0078	36.63	40.90 ± 0.02	0.0068
Species of concern	136.11	147.68 ± 0.12	0.0049	73.32	85.04 ± 0.03	0.0001

TABLE 3. Logistic regression coefficients and upper and lower 95 % confidence intervals (C. I.) predicting occurrence across a habitat gradient for members of the mature forest (MF), insect-foliage (IF), canopy nesting (CN) and conservation concern (CC) species groups detected in 1997. The confidence intervals of the species in bold face do not overlap with the confidence interval of the Cerulean Warbler.

Species	Functional group	Regression coefficient	Lower 95 % C. I.	Upper 95 % C. I.
Cerulean Warbler (*Dendroica cerulea*)	all	0.519	0.121	0.917
American Redstart (*Setophaga ruticilla*)	all	0.144	-0.299	0.587
Ovenbird (*Seiurus aurocapilla*)	MF, CC	0.475	0.024	0.926
Black-and-white Warbler (*Mniotilta varia*)	MF	-0.290	-0.645	0.065
Scarlet Tanager (*Piranga olivacea*)	all	0.106	-0.239	0.451
Least Flycatcher (*Empidonax minimus*)	MF, CN, CC	0.116	-0.290	0.522
Yellow-throated Vireo (*Vireo flavifrons*)	MF, IF, CN	0.066	-0.381	0.513
Wood Thrush (*Hylocichla mustelina*)	MF, CC	-0.287	-0.791	0.217
Black-throated Green Warbler (*Dendroica virens*)	MF, CN, CC	0.134	-0.272	0.540
Northern Waterthrush (*Seiurus noveboracensis*)	MF	-0.195	-0.777	0.387
Warbling Vireo (*Vireo gilvus*)	IF	-0.995	-1.936	-0.054
Ruffed Grouse (*Bonasa umbellus*)	MF	-0.140	-0.620	0.340
Veery (*Catharus fuscescens*)	MF, CC	-0.622	-1.786	0.542
Yellow-rumped Warbler (*Dendroica coronata*)	MF, IF, CN	0.009	-0.483	0.501
Common Yellowthroat (*Geothlypis trichas*)	IF, CC	-0.192	-0.555	0.171
Golden-winged Warbler (*Vermivora chrysoptera*)	IF, CC	-0.534	-0.955	-0.113
Indigo Bunting (*Passerina cyanea*)	IF, CC	-0.535	-0.974	-0.096
Chestnut-sided Warbler (*Dendroica pensylvanica*)	IF, CC	-0.705	-1.438	0.028
Yellow Warbler (*Dendroica petechia*)	IF	-0.232	-0.585	0.121
Black-capped Chickadee (*Poecile atricapillus*)	IF	0.058	-0.279	0.395
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	IF, CC	-0.725	-1.270	-0.180
Baltimore Oriole (*Icterus galbula*)	IF, CN, CC	0.281	-0.217	0.779
Blue-grey Gnatcatcher (*Polioptila caerulea*)	IF, CN	-0.279	-0.781	0.223
Cedar Waxwing (*Bombycilla cedrorum*)	CN	-0.066	-0.440	0.308
Blue Jay (*Cyanocitta cristata*)	CN	-0.873	-1.528	-0.218
Eastern Wood-Pewee (*Contopus virens*)	CN, CC	-0.202	-0.670	0.266
American Crow (*Corvus brachyrhynchos*)	CN	-0.304	-0.835	0.227

foliage and conservation concern groups exhibited less concordance with the Cerulean Warbler distribution relative to the habitat gradient – 43% (6 of 14) and 29% (4 of 14), respectively.

Discussion

Effective biodiversity indicators tend to be habitat specialists with wide geographic ranges; they also tend to have well-known natural histories (Caro and O'Doherty 1999). Despite fitting this profile (Hamel 2000; Oliarnyk 1996; Jones 2000; Barg 2002), our results indicate that the Cerulean Warbler would not be particularly effective as an avian biodiversity indicator in eastern Ontario, as its distribution across the studied landscape did not coincide with areas of high avian species richness.

Our co-occurrence and logistic regression results do suggest that the Cerulean Warbler is suited to a role as an umbrella species. Perhaps not surprisingly, the distribution of the Cerulean Warbler was well matched to the distributions of other canopy nesters in mature deciduous forest (e.g., Scarlet Tanager, *Piranga olivacea*). Given the hierarchical nature of habitat selection, broad habitat requirements are likely more impor-

tant in determining species distributions than are species' food and nesting requirements (Hutto 1985; Block and Brennan 1993); indeed, we found that the species grouped by diet were more variable in their distributions along our succession gradient than were the species grouped by habitat type or nest location. Small body size — and, as a consequence, small home range size (Barg et al. in press) — could limit the Cerulean Warbler's umbrella suitability, as effective umbrella species tend to have large home ranges (Caro and O'Doherty 1999); however, the Cerulean Warbler's apparent tendency to live in conspecific aggregations (Hamel 2000) potentially offsets any limitation imposed by small body size and individual home range size. We do not mean to suggest that the Cerulean Warbler would be a better umbrella than other, more widespread, species such as the Scarlet Tanager. Rather, our conclusions suggest that, if habitat management is directed at Cerulean Warblers, other species will likely benefit.

Our co-occurrence and logistic regression results highlight a potential management conflict between mature forest and shrubland species. Although our *C*-scores indicate significant patterns of co-occurrence within the conservation concern group, there was no overlap between the logistic regression confidence intervals of the Cerulean Warbler and shrubland species that are considered to be at risk, such as the Golden-winged Warbler (*Vermivora chrysoptera*). Given their disparate habitat requirements (i.e., forest edge vs. forest interior), management for Golden-winged Warblers will necessarily conflict with management aimed at maximizing Cerulean Warbler population health.

One additional conservation role the Cerulean Warbler may fill, and may be already filling, is that of a flagship species: a species that attracts attention support by virtue of its 'charismatic' nature (Simberloff 1998). The Cerulean Warbler is a Neotropical migrant songbird, a group of birds that has been in the conservation spotlight over the last 30 years (e.g., Robbins et al. 1989b). The Cerulean Warbler is a beautiful bird with an elusive nature that has a high profile due to extensive public education and activism (Rosenberg et al. 2002) and is highly valued by birders and ornithologists alike. More recently, the Cerulean Warbler has achieved notoriety as the focus of a legal battle surrounding its candidacy for listing on the U.S. Endangered Species Act (Ruley 2000). This attention has led to the development of the CWTG and has spurred a great deal of basic research and forest management interest (Hamel et al. 2004). The apparent dependence of this species on large tracts of forest creates a possibility for the Cerulean Warbler to serve as a valuable symbol of the overall health of deciduous forests in eastern North America.

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Parasite Prevalence in Dark-eyed Juncos, *Junco hyemalis,* Breeding at Different Elevations

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During the summer of 2001, Dark-eyed Juncos (*Junco hyemalis*) were captured within the lowest (1000 m above sea level) and highest (2000 m asl) elevation extremes of their breeding range in Jasper National Park, Alberta. Blood samples were taken to identify parasite genera, and to test for differences in parasite prevalence among elevations. The most common parasites at either elevation were *Haemoproteus* spp., *Leucocytozoon* spp., and *Trypanosoma* spp. A significantly higher proportion of low- compared to high-elevation birds was infected by at least one of these, supporting the prediction that high-elevation habitats may be refuges from parasites.

Key Words: Dark-eyed Juncos, *Junco hyemalis*, blood parasites, mountains, elevation, Alberta.

Birds breeding at high elevations often experience a delayed date of reproductive onset, exposure to extreme weather, and scarce or sparsely distributed resources (Hamman et al. 1989; Landmann and Winding 1993; Kollinsky and Landmann 1996; Widmer 1999; Bears et al. 2003). Dark-eyed Juncos (*Junco hyemalis*) show a significant reduction in seasonal reproductive output with increasing breeding elevation from the montane valley (1000 m asl) to the subalpine-alpine treeline (2000 m asl) in Jasper National Park, Alberta (Bears 2002, Bears et al. 2003). Yet, high elevation habitats are not occupied by less competitive age or size classes of juncos, or by later arriving individuals (Bears 2002), all of which are traits that render juncos less successful competitors for territory (Cristol et al. 1990; Grasso et al. 1996). Further, inter-annual return of birds to their site of capture is high, and roughly equivalent among elevations (Bears 2002). Hence, it does not appear that juncos are "forced" to breed at high elevations due to intraspecific competitive exclusion from lower-elevation habitat. This led me to explore the idea that high-elevation juncos are compensated for decreased seasonal reproductive output over their lifetimes by some unrecognized benefits of breeding at high elevations. In other mountain ranges, studies have shown that the blood parasites of birds, and the insect vectors that carry them, tend to be low at upper breeding elevations (Stabler et al. 1974; Braun et al. 1993). Thus, as part of a series of investigations into the benefits of high-elevation breeding, I tested whether the juncos have fewer parasites within higher- versus lower-elevation segments of their breeding range in Jasper.

Methods

Juncos were captured and monitored at eight 50 – 70 ha study sites in Jasper National Park (52°53'N, 118°3'W), Alberta, from 1 May to 20 August in 2000, and from 15 April to 20 August in 2001. Four sites were located near the lowest elevation within the Park (1000 – 1020 m asl), separated by 5-10 km. Four sites were at the highest elevation at which juncos breed within the park (1950-2100 m asl), and were separated by > 18 km. All high-elevation sites had south or southest aspects. Morphological measurements taken from juncos in these sites (H. Bears, unpublished data) most closely match the Oregon subspecies, *Junco hyemalis oregonus* (Miller 1941), but some appear to be intergrades between *Junco hyemalis oregonus* and *Junco hyemalis hyemalis*, which produces *Junco hyemalis cismontanus* (Miller 1941). Subspecies designations of Dark-eyed Juncos are a capricious topic based on phenetic rather than genetic data, and they are a taxonomic nightmare in the Canadian Rockies where multiple subspecies meet and hybridize. Therefore, we refer to the birds analyzed here simply as *Junco hyemalis.*

Birds were captured using Japanese mist nets with painted model male juncos as decoys. Juncos were lured towards the net by playing the taped song of a conspecific. Birds were given a numbered Canadian Wildlife Service leg band and colour bands that conveyed sex, age, and site information when caught. Blood samples were taken from each bird caught between 1 May and 20 August in 2001 only by puncturing the alar vein with a needle and collecting ca. 40 μl of blood in a heparinized microhematocrit tube.

Blood was blown out of microhematocrit tubes into centrifuge tubes and kept on wet ice. Because blood parasites may follow a diurnal periodicity (Gore et al. 1982), the birds selected for parasite identification were caught at approximately the same time each day (7:00-12:00 hrs). Within 10 hours of collection, 5 µl of blood were used to produce three microscope slides per bird, using the methods of Harrison and Harrison (1986) and Bennett (1970). The slides were fixed in 100% methanol immediately. In the laboratory, blood smears were stained with Geimsa stain for 30 minutes, and rinsed with distilled water followed by acetone under a fumehood (Deviche et al. 2001). Smears were examined under 400 × 10 magnification, and 50 fields of view per slide were classified as negative or positive for various parasites. Parasites were identified to the genus level by examination under high power (1000 × magnification) with oil immersion, using various keys (Pierce 1981; Bennett and Pierce 1988; Burrey-Caines and Bennett 1992; Bennett et al. 1994), and by comparing with photos of blood parasites taken from juncos captured in Alaska (supplied by Pierre Deviche, Arizona State University, personal communication). Parasite species were difficult to ascertain with absolute certainty, but the genus level could be resolved without ambiguity. Therefore, we used the genus level when comparing parasite prevalence among elevations.

At each site, one bird was caught between the 1st and 5th of each month (May-August), and another between the 11th and 15th of each month, in order to represent sites and time periods within the breeding season equivalently. No females were captured using playback and mist-netting methods, and so analyses here deal solely with males. The statistical significance level for all tests conducted was set at $\alpha = 0.05$. All tests were performed using SPSS 10. All techniques used were approved by the animal care committee of the University of British Columbia (A0-0046), Parks Canada (2000-008), and Environment Canada (Banding: 10429 AJ; Collection: BC SCI 2000/067).

Results

Thirty-two high- and 32 low-elevation adult male birds caught across all eight sites were used in these analyses. In addition, 12 fledglings were caught at high elevations (in August) and 12 were caught at low elevations (in August). Three parasite genera were found in the blood of juncos: *Haemoproteus* (Family Plasmodiidae), *Leucocytozoon* (Family Plasmodiidae) and *Trypanosoma* (Family Trypanosomatidae). All data are summarized in Table 1. The most prevalent blood parasite at both elevations was *Haemoproteus*, followed by *Leucocytozoon*, and *Trypanosoma*. A significantly higher proportion of low-elevation birds (66%, 21/32) compared to high-elevation birds (28%, 9/32) were infected by at least one of these parasites (P = 0.002, Fisher's Exact Test). A higher percentage of low-elevation birds (34%, 11/32) compared to high-elevation birds (19%, 6/32) were infected with *Haemoproteus* spp., but the difference was not significant (P = 0.08, Fisher's Exact Test). Similarly, more low-elevation birds (25%, 8/32) versus high-elevation birds (9%, 3/32) were infected with *Leucocytozoon* spp., with a near significant difference (P = 0.07, Fisher's Exact Test). Of these individuals, 42% (8/19) of low-elevation and 44% (4/9) of high-elevation birds had both *Haemoproteus* spp. and *Leucocytozoon* spp. present in their blood. Two cases of infection with *Trypanosoma* spp. were found in low-elevation birds, and none at high elevations. Thirty-four percent (11/32) of low-elevation and 72% (23/32) of high-elevation birds were not infected with any parasites. There was no relationship between date of capture and infection at low elevations (P = 0.23, r = 0.33; Pearson's r). However, at high elevations, a low proportion of individuals (12.5%, 2/16) caught between 1 May and 15 June were infected with *Leucocytozoon* spp. and *Haemoproteus* spp., but between 15 June and 30 August, a significantly higher proportion were infected (7/16, 44%; P = 0.05, Fisher's Exact Test). In samples from low elevations not used in this analysis (taken from birds nearby, but not within our study areas) two cases

TABLE 1. Summary of data on presence and absence of blood parasites in Dark-eyed Juncos from low (~1000 m asl) and high (~2000 m asl) elevations.

Adults (ASY)	*Infection/Parasite*	*Low (N = 32)*	*High (N = 32)*
	Infected	21	9
	Trypanosoma present	2	0
	Leucocytozoon present	8	3
	Haemoproteus present	11	6
	Both *Haemoproteus* and *Leucocytozoon* present	8 of 19 individuals	4 of 9 individuals
	no parasites	11	23
Fledglings	*Parasite*	*Low (N = 12)*	*High (N = 12)*
	Leucocytozoon *present*	2	1

of *Plasmodium* spp. (family Plasmodiae) were noted. More fledglings were infected with *Leucocytozoon* spp. at low elevations as compared to at high elevations (17%, 2/12, vs 8.3%, 1/12), but the difference was not significant (P = 0.39, Fisher's Exact Test). No other blood parasites were observed in fledglings.

Discussion

High-elevation adult males and fledglings had lower incidences of blood parasites as compared to low-elevation adult males and fledglings. If relief from parasites enables adults to survive longer and breed for more years, then this could aid in equalizing the lifetime reproductive success of high- and low-elevation birds. Blood parasites can decrease survivorship by directly increasing susceptibility to predation (Vaughn and Coble 1975). In addition, there may be a trade-off between reproductive effort and the efficiency of the immune response. For instance, parasite loads may increase during the reproductive period, as they did here at high elevations, when breeding adults spend considerable time provisioning their young and in nest and territorial defence, or when breeding effort is increased experimentally (Ots and Horak 1996; Norris et al. 1994; Weatherhead and Bennett 1991, 1992; Rintmaki et al. 1999). A simpler reason for the differential susceptibility observed here might also be due to a difference in the timing of emergence of the insect vectors carrying the parasites.

The two most common parasite genera in this study, *Haemoproteus* and *Leucocytozoon*, are protozoon parasites of birds. *Haemoproteus* spp. are primarily transmitted by insects in the dipteran family Ceratopogonidae (no-see-ums, sandflies) or Hippoboscidae (louse flies), whereas *Leucocytozoon* spp. are primarily transmitted by simuliids (e.g., black flies) (Greiner and Ritchie et al. 1994; Rosskopf and Woerpel 1996; Rintmaki et al. 1999). *Trypanosoma* (likely *avium*), which was rare in our study, is also transmitted by members of the family Simuliidae. The principal effects of *Leucocytozoon* infections are intravascular haemolytic anemia, weight loss, and sometimes death, whereas *Haemoproteus* and *Trypanosoma* in birds are generally less pathogenic (Greiner and Ritchie 1994). Finally, two low-elevation samples (not analyzed as part of the sub-samples selected) contained *Plasmodium* spp., which is transmitted by mosquitos (family Culicidae). Almost all of these insect vectors were noted to have emerged later at high elevations, perhaps preventing exposure of birds to the parasites for much of the season. High-elevation birds were also at lower densities (Bears 2002), and therefore transmission between birds may have been lower.

Results suggest that high-elevation habitats may be of conservation importance in limiting the spread of blood parasites in birds. The Canadian Rockies may play a particularly important role in limiting the rate at which avian diseases travel east and west across the Rocky Mountains. Further work, including comparisons of parasite levels in females, and in other species that breed over wide elevation ranges, is required in order to assess the generality of this parasite refugium hypothesis in the Rocky Mountains of Canada. Mechanisms by which high-elevation birds are protected from parasites should also be explored.

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Movements of Subadult Male Grizzly Bears, *Ursus arctos,* in the Central Canadian Arctic

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Between May 1995 and June 1999, we equipped eight subadult male (3-5 yrs old) Grizzly Bears (*Ursus arctos*) with satellite radio-collars within a study area of 235 000 km^2, centred 400 km northeast of Yellowknife, Northwest Territories, Canada. Subadult male annual home ranges were extraordinarily large (average = 11 407 km^2, SE = 3849) due, in part, to their movement's occasional linear directionality. We believe their long-range linear movements may reflect some individuals tracking the migration of Caribou (*Rangifer tarandus*). Seasonal daily movement patterns were similar to adult males that were previously reported. The areas used by these bears are the largest ranges reported for any Grizzly Bears and the scale of their movements may put individual bears in contact with humans even when developments are hundreds of kilometres from the central home range of an animal.

Key Words: Grizzly Bear, *Ursus arctos,* home range, movements, subadult, central Arctic, Northwest Territories.

The population of Barren-ground Grizzly Bears (*Ursus arctos*) in the Northwest Territories (NWT) exists at a low density in the tundra and is considered "sensitive" after a recent species-at-risk assessment (Government of the NWT, 2000). As such, there is concern for any increase in human presence that might impact on their numbers.

Economic activity in the central Arctic of the NWT and Nunavut increased dramatically in the early 1990s with the discovery of diamonds. At present there are three mines (two diamond, one gold) and numerous base-metal, gold, and other diamond developments in the region. To address the effects of these developments, in 1995 the Government of the NWT and the University of Saskatchewan initiated the first multifaceted research program into the ecology of Barren-ground Grizzly Bears inhabiting the central Arctic.

One aspect of our research program was to detail the spatial requirements of the Barren-ground Grizzly Bears in this region (McLoughlin 2000). However, incidental to our primary objectives, we obtained data on large-scale movements of some subadult male bears (3-5 yrs old) that were also captured and monitored. Although many aspects of bear ecology have been well documented, descriptions of dispersal and movement patterns for subadult Grizzly Bears remain rare and difficult to obtain (McLellan and Hovey 2001). While progress with DNA analysis may shed insights on subadult dispersal in the future (see Waits et al. 1999; Woods et al. 1999; Woods and Strobeck 2000), current methods to examine dispersal in bears generally require marking young animals to identify when captured or killed at a later date, or radio tracking 2- and 3-year olds captured prior to or immediately following separation from their mother. Our findings parallel and complement McLoughlin et al. (1999) and McLoughlin et al. (2003).

Methods

The study area was centred in Canada's central Arctic (66°10'N, 111°25'W), encompassing approximately 235 000 km^2 of mainland Nunavut and the NWT (Figure 1). The study area was delineated by the community of Kugluktuk, the Kent Peninsula, Aylmer Lake, Mackay Lake, and Great Bear Lake. We previously noted the biophysical characteristics of the region in Gau et al. (2002).

Between May 1995 and June 1999, helicopters were used to search for and capture bears. Bears weighing >110 kg (males) and >90 kg (females) were fitted with tracking devices. There were the minimum weights we considered bears robust enough to wear a collar safely. We considered most two- and three-year-old bears too small and growing too rapidly to be fitted with satellite collars. Some telemetry methods (e.g., inserts or breakaways to collar belting, ear-tag transmitters, expandable radio-collars) show promise; however, improvements are still needed (Costello et al. 2001).

Satellite (Service Argos Inc., Landover, Maryland, USA) and conventional VHF radio-telemetry (Telonics Ltd., Mesa, Arizona, USA) were used to obtain spatial information on Barren-ground Grizzly Bears. Most

TABLE 1. Subadult male Grizzly Bears, and their periods of long-range (>200 km) linear directional movement, captured and collared between 1995 and 1999 in the central Canadian Arctic.

Bear	Age	Year	Number of locations	95% fixed kernal range (km²)	Mean Daily Movement (km/day) Spring	Summer	Late summer	Autumn	Linear Directional Movements Distance covered (km)	Number of days
G595	4	1995	103	15 899	7.5	10.4	6.2	7.9	539	57
G600	3	1995	129	22 007	16.6	8.8	10.5	7.7	779	59
G612	4	1995	91	4448	24.8	9.7	4.0	11.7	471	23
									446	33
G618	5	1995	66	4540	6.1	6.7	9.5	5.6		
G656	5	1996	45	32 188	n/a [1]	n/a [1]	n/a [1]	n/a [1]	273	26
									305	40
G657	5	1996	42	6162	n/a [1]	n/a [1]	n/a [1]	n/a [1]		
G689	4	1998	58	3662	n/a [1]	n/a [1]	n/a [1]	n/a [1]		
G700	4	1998	64	2349	7.9	5.9	4.2	5.1	201	32

[1] <8 locations/season in every season of the year were recorded thus omitted from analysis.

collars were designed to transmit approximately 2-5 latitude-longitude locations every two days (8-hour duty cycle) from 1 May to 1 November.

Our calculations and techniques for study of animals, ranges from satellite telemetry locations and rates of movement (km/day) were previously described in McLoughlin et al. (1999) and McLoughlin et al. (2003). Annual home ranges were determined using the 95% isopleth for bears only with ≥38 locations, so as not to overestimate range size with smaller sample sizes (Seaman et al. 1999). Also, only those animals that transmitted ≥8 locations/season in every season of the year were included for analysis. We defined seasons according to changes in the diet of Barren-ground Grizzly Bears during the active period (adapted from Gau et al. 2002), including spring (den emergence-20 June), summer (21 June-31 July), late-summer (1 August-9 September), and autumn (10 September-den entrance).

Results

Of the male bears that were not in a family group with their mother, 6 of the 45 males handled were too small for collaring. However, we did collar and monitor 8 subadult males between 3 and 5 years of age out of a sample of 39 collared males (Table 1). Male subadult movements were extraordinarily large and annual home range averaged 11 407 km² (SE = 3849, range 2349 – 32 188).

A unique feature of the subadult movements we observed consisted of periods of long-range (>200 km) linear directional forays. Five of the eight subadults we followed exhibited this linear movement pattern. For example, 4-year-old bear G612 in 1995 moved 471 km from 31 May to 22 June along a northerly trek from the treeline to the Arctic coast. While the other movements may not be as dramatic as G612 in terms of time a distance was covered, long-range linear directional movement appeared common for subadult males in this Barren-ground Grizzly population. Bears G595, G600, G612, and G656 had linear directional movements in the spring; additionally, bears G612, G656, and G700 had autumn linear directional movements.

The subadult males followed a seasonal daily movement pattern similar to adult males (see McLoughlin et al. 1999). Only five bears met our criteria to investigate seasonal movements. Means were 12.6 km/d (SE = 3.6), 8.3 km/d (SE = 0.9), 6.9 km/d (SE = 1.3), and 7.6 km/d (SE = 1.2) for spring, summer, late summer, and autumn, respectively. There was a clear general trend from a high rate of movement (spring) to lower rates for the rest of their active period, although an ANOVA determined no significant differences between seasonal means ($F_{3,16} = 1.6$, $P = 0.2$).

Discussion

The annual ranges of adult and subadult Barren-ground Grizzly Bears in the central Canadian Arctic are the largest ranges yet reported for grizzlies in North America (see Table 1, McLoughlin et al. 1999). However, there are very few published data about subadult Grizzly Bear movement patterns either to refute or support our claim (McLellan and Hovey 2001). Jonkel (1987), along with Mace and Waller (1997), noted that dispersing immature brown bears tended to have smaller home ranges than adult male bears. However, LeFranc et al. (1987), along with Nagy et al. (1983), summarized examples where subadults, believed dispersing from maternal home ranges, had home ranges as large or larger than those of adult males. Regardless, the magnitude of the movement patterns we observed eclipses other results that have been previously published.

We have gleaned valuable insights into the movement patterns of Canadian Barren-ground Grizzly Bears. Mean annual ranges were 7245 km² for adult males and 2100 km² for females, with no difference in

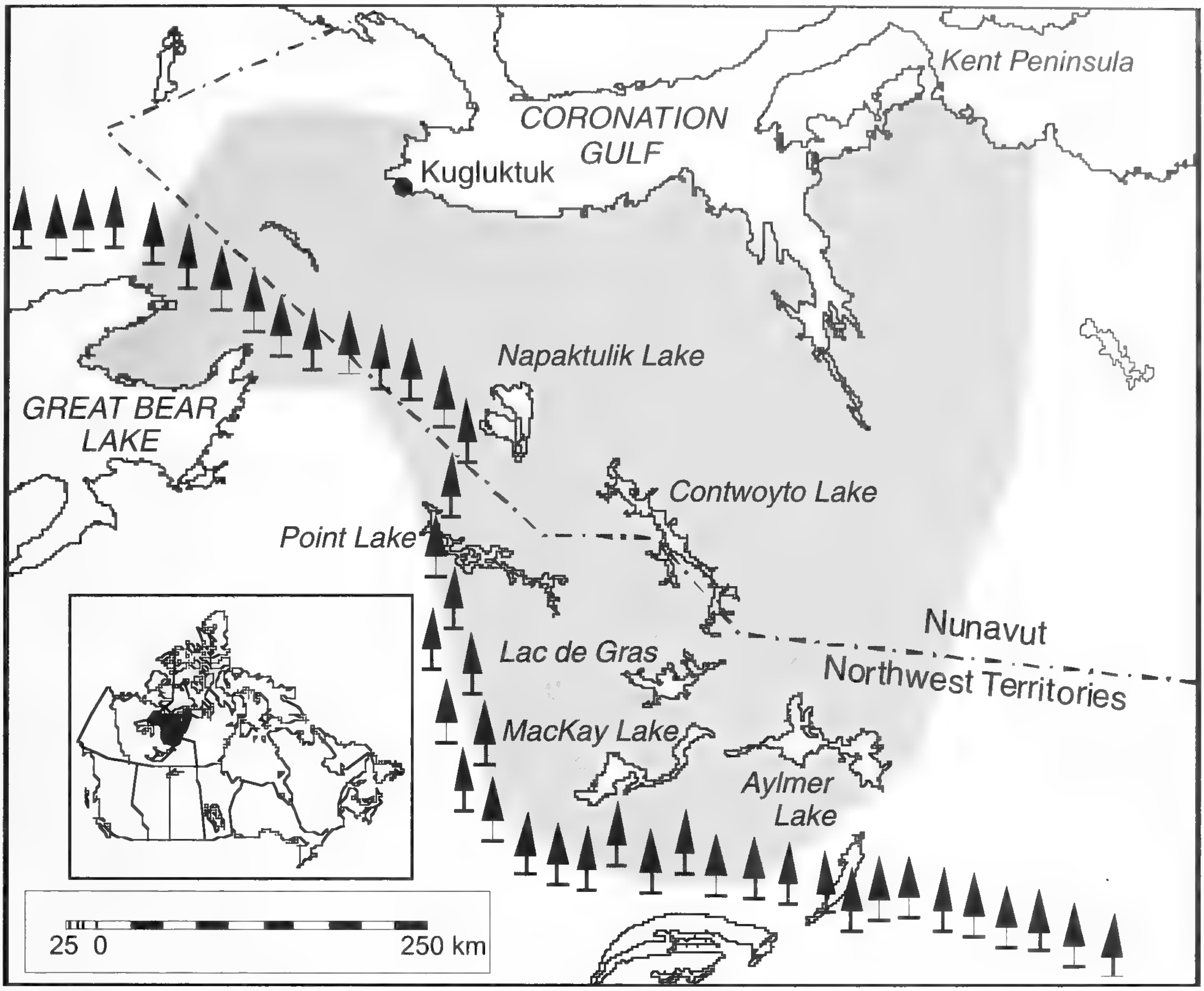

FIGURE 1. Location of the study area in Canada's central Arctic. The treeline indicates the approximate northern limit of coniferous forest in the region.

the ranges for females of differing family status (McLoughlin et al. 2003). The large disparity between adult males and females (5145 km^2), and especially between subadult males and females (9307 km^2), is interesting since females introduce younger male bears only to a seemingly small portion of the land they will eventually use in the central Arctic. Although we can expect a high degree of movement and population overlap among males in the central Arctic (McLoughlin et al. 2002), it is possible that some of the subadult male ranges we recorded were somewhat inflated. We suspect that some bears in this study tracked the spring migration of Caribou (*Rangifer tarandus*), a behaviour previously suspected in northern Alaska for Barren-ground Grizzlies (Reynolds and Garner 1987).

At the daily and seasonal movement rates we observed for subadult males, because of their similarity to adult male daily movement rates, it would be possible for subadult males to have home range sizes typical of male adults in the region. However, the unique feature of the subadult movements we observed appeared to be their occasional linear directionality. Other than homing behaviours of transplanted bears (Miller and Ballard 1982), extended directional movements are rare (McLellan and Hovey 2001). Explanations for long-range bear movements include seeking out quality habitat, spacing behaviour resulting from social interactions with other bears, the abundance and distribution of food (e.g., following migrating caribou herds), inbreeding avoidance, and maximizing reproductive fitness, or dispersal immediately following separation from their mother (Rogers 1987; Pasitschniak-Arts and Messier 2000). All these factors likely contributed to the movement patterns of subadult males in the Canadian central Arctic. McLoughlin et al. (1999) also pointed out that Barren-ground Grizzly Bears have larger scale movements when compared to other grizzly populations principally due to low primary productivity in the tundra environment.

The spatial behaviour of subadult male grizzlies increases their probability of coming in contact with humans even when sites of human activity (e.g., ex-

ploration and hunting camps, industrial developments, and communities) are of considerable distance from the central home range of an individual. Subadult bears in particular do not have the life-experience of mature bears, are often imbued with more curiosity, and thus are highly susceptible to human activity. Management of bears in the central Arctic should focus on maintaining low levels of human-caused mortality of bears, with the realization that communities, hunting camps, and mining/exploration camps may impact bears from more than just the general vicinity. Also, the widespread movements of subadult bears are a compelling argument for a comprehensive and consistent bear conflict avoidance program throughout the central Arctic. Developments that might not be considered in optimum Grizzly Bear habitat should have the tools or resources to effectively manage potential problem bears.

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Severe Chronic Neck Injury Caused by a Snare in a Coyote, *Canis latrans*

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Daoust, Pierre-Yves, and Peter H. Nicholson. 2004. Severe chronic neck injury caused by a snare in a Coyote, *Canis latrans*. Canadian Field-Naturalist 118(2): 243-246.

A two-year-old male Coyote, *Canis latrans*, in poor body condition was found in a moribund state with a snare deeply embedded in the ventral portion of its neck, more than a month after the official end of the trapping season on Prince Edward Island. This snare had presumably malfunctioned, and the cable had cut through the soft tissues of the neck as well as the trachea and had obstructed both jugular veins and both common carotid arteries but had largely spared both vagosympathetic trunks. Cases like this illustrate the need to continue to work on improving the efficiency of trapping methods, through research and trapper education.

Key Words: Coyote, *Canis latrans*, trapping, injury, snare, Prince Edward Island.

Animal welfare issues surrounding trapping methods used to capture furbearers have been an ongoing topic of discussion between wildlife managers and animal protection groups for many years (Proulx and Barrett 1991). Because of this and of the economic importance of the fur trade to Canada, this country has taken a leading role in developing national and international standards for the performance of restraining- and killing-type traps. In the section of the Agreement on International Humane Trapping Standards (AIHTS) (1997*) dealing with killing type traps such as the commonly used rotating-jaw Conibear trap, the designated time limit to irreversible loss of corneal reflexes in at least 80% of the animals of the target species caught in the trap varies from 45 seconds in Ermine *(Mustela erminea)* to 120 seconds in Pine Marten *(Martes americana)* to 300 seconds in 17 other species of North American and European furbearing animals. This Agreement requires that the parties involved continue research with a view to lowering the threshold requirements. Nonetheless, it implicitly recognizes that no killing trapping method used to capture wild animals can as yet guarantee a humanely acceptable process in each instance. Manual neck snares (where the animal provides the energy necessary to tighten the snare) are widely used by trappers to capture various furbearing animals, and Guthery and Beasom (1978) and Boddicker (1982) discussed the advantages and disadvantages of snares as compared to other trapping devices. Snares are allowed in most Canadian jurisdictions, except the southern regions of some provinces. Being considered devices that are constructed by the trappers themselves, they are not subject to the testing requirements under the AIHTS (1997), but their design must be approved by relevant competent authorities such as provincial Departments of Wildlife. This article describes an unsuccessful capture by snare of a Coyote *(Canis latrans)*, with severe consequences.

Case Description

On 26 February, 2002, a male Coyote, subsequently determined to be 2 years old (Matson's Laboratory, Milltown, Montana, USA), was found alive but moribund in a field in Kings County (46°08'N, 62°36'W), Prince Edward Island (PEI), and was euthanized by a shot to the head. It was submitted for necropsy to the Diagnostic Laboratory of the Atlantic Veterinary College, University of PEI. Postmortem examination revealed that the animal had been caught in a snare and had managed to escape. The snare's cable, made of galvanized steel wire 2 mm in diameter, was equipped with a standard U-shaped lock, similar to an Adams lock. The snare surrounded the animal's neck, with a portion of cable approximately 20 cm long dangling beyond the neck. The coyote was in poor body condition; the stomach was completely empty, and the intestines contained only a small amount of ingesta. However, some fat was still present around the base of the heart, and a sample of diaphyseal bone marrow from one of the femurs contained approximately 54% fat, as measured by comparison of the wet and dry weights of the sample. A large area of the skin along the ventral side of the neck, about 50 cm^2, was missing and had been replaced by scar tissue that released a foul odour indicative of suppuration. The portion of the cable along the ventral side of the neck had transected the full diameter of the trachea and was embedded in scar tissue between the trachea and the esophagus (Figure 1). The wall of the severed portion of the trachea was completely healed, although the tissue of repair had extended as a thin circular band

into the tracheal lumen, reducing its surface area to about one-seventh of its original size (Figure 2). The esophageal lumen was patent. There was no gross evidence of suppuration accompanying the scar tissue that surrounded the trachea and the cable. At the time of necropsy, the cable was freely movable within the affected tissues. The architecture of both jugular veins disappeared at the level of the scar tissue. A thin probe inserted into the cranial portion of the common carotid artery on both sides of the trachea was blocked from further progression at this level. The outline of the vagosympathetic trunk on both sides was also lost among the scar tissue. No other significant lesion was seen at necropsy. Samples of the affected portion of trachea and surrounding soft tissues were fixed in formalin, processed routinely for microscopic examination, and stained with hematoxylin and eosin.

Microscopically, the scar tissue surrounding the affected portion of trachea consisted of abundant dense fibrous tissue, much of which was birefringent under polarized light. This fibrous tissue enclosed several pockets of necrotic material (including debris of inflammatory cells) and, in some areas, contained numerous cross sections of hair shafts. Serial sections of this tissue, parallel to the length of the trachea, revealed on both sides an artery, about 3 mm in diameter, and a nerve, about 1 mm in diameter. Taking into account the shrinkage that normally occurs in tissues processed for microscopic examination, the diameters of these two structures were compatible with those of the common carotid artery and vagosympathetic trunk, respectively, for an animal of this size. Depending on the section examined, the lumen of the common carotid artery on both sides of the trachea was either empty or partly or completely filled with a well organized thrombus. The vagosympathetic trunk on both sides was morphologically normal, except for a few degenerative lesions suggesting some loss of axons and their myelin sheaths (wallerian degeneration). The tissue within the tracheal lumen also consisted of dense fibrous tissue that enclosed some necrotic material and numerous cross sections of hair shafts.

Discussion

Ideally, a snare should cause rapid death by neck strangulation and subsequent asphyxiation. A quick death is more humane and also gives the animal less time to find a way out of the snare. A variety of factors can influence the performance of a snare. Some locking mechanisms tighten less quickly and firmly than others (Phillips 1996), or small kinks in the cable may weaken it and make it easier to break or may prevent full function of the lock. Inclusion of a swivel attaching the lock to the cable (not present in this case) can prevent the cable from kinking as the lock slides along it. If the cable is not anchored firmly enough, the animal may be able to pull off the snare before maximum closure has been achieved. If death is not rapid and the cable is anchored too low, it may be more easily accessible to the animal's jaws and be chewed through. Seventeen of 131 (13%) Coyotes caught by one of three types of snares studied by Phillips (1996) managed to escape, one by breaking the lock and 16 by chewing through the cable.

In this Coyote, the relative abundance and density of the scar tissue in the neck and, microscopically, its birefringence under polarized light suggested that the failed capture had occurred at least a few weeks prior to death. The trapping season for Coyote and Red Fox *(Vulpes vulpes)* on PEI officially terminated on January 15, more than a month before this animal was found. The reason why it managed to escape capture was not determined, although the portion of cable dangling from its neck was of the right length to suggest that the animal had chewed through it rather than pull the whole cable from where it was anchored. Unfortunately, the animal's gums and teeth were not examined for the presence of recent damage that would have supported this suggestion. At the time of escape, sufficient closure of the snare may have already been achieved for the cable to exert a strong pressure on soft tissues of the ventral side of the neck and be forced gradually through these tissues over the following weeks. Gradual transection and concurrent repair of the tracheal wall would thus have allowed it to remain continuous. Alternatively, transection of all soft tissues, including the trachea, could have occurred at the time of the animal's initial struggle in the snare. Such rapid transection of the trachea, however, would more likely have resulted in the formation of a gap between its cut ends, thus preventing them from healing together. Moreover, if the trachea had been rapidly transected, the jugular veins would probably also have been cut and the animal would presumably have bled to death. The thicker hair coat and skin on the dorsal side of the neck as compared to the ventral side (Scott et al. 2001) and the tough nuchal ligament on the dorsal side (Evans 1993) may have prevented the cable from moving into the tissues from that side.

The common carotid arteries and the vagus nerves are important structures running along both sides of the trachea. In this animal, the lumen of both common carotid arteries was occluded. However, this is not a critical problem, at least in canids. In dogs, both common carotid arteries can be ligated experimentally without causing any clinical signs, implying that collateral circulation (e.g., via the vertebral arteries) is able to quickly compensate and transport sufficient blood to the brain (Whisnant et al. 1956). Such collateral circulation would have even more time to develop if the obstruction were gradual, as is suspected to have occurred in this case. The same reasoning applies to the jugular veins, located much more superficially in the ventral region of the neck, since collateral circulation within the venous system can develop even more readily than in the arterial side. Proper function

FIGURE 1. Right lateral view of the neck of a Coyote. The carcass is lying on its back, with the head to the left. The cable from a snare has cut through the trachea (T) and is now lodged between it and the esophagus (E). The distortion of the wall of the trachea just above the cable as been caused by scar tissue of repair. A metal rod has been inserted in the lumen of the esophagus. The common carotid artery (C) and vagosympathetic trunk (V) are clearly visible to the left of the cable. The lock of the snare is at the bottom of the picture. (Bar = 2 cm.)

of at least one of the vagosympathetic trunks is, however, essential to life. The vagal (parasympathetic) portion of these nerves originates in the brain and supplies efferent and afferent innervation to many vital organs, including the cardiovascular system and digestive tract (Andrews and Lawes 1992; Esler 1992; Guyton and Hall 1996). In particular, vagal stimulation protects against excessive stimulation of cardiac function by the sympathetic nervous system during physical activity and stress. In this Coyote, it was not possible to dissect the vagosympathetic trunk on either side of the affected portion of trachea, because both trunks were well embedded in scar tissue at this level. However, careful microscopic examination showed that both trunks were in large part morphologically intact. Although their structure had likely been stretched, and their path distorded, by the cable, the gradual process through which this happened would presumably have provided sufficient time for anatomic and physiological compensation.

The exact cause of the eventual demise of this coyote was not clear. There are undocumented reports by veterinary practitioners of collars being left permanently on growing dogs and eventually becoming buried under the skin, with damage limited to chronic suppuration of the subcutis (J. B. Miller, Department of Companion Animals, Atlantic Veterinary College, University of PEI, personal communication). Similarly, a square of a monofilament gillnet mesh was found almost totally embedded in the snout of an otherwise healthy Porbeagle *(Lamna nasus)* that had been caught on the Scotian Shelf (Benz et al. 2001). However, the marked reduction in size of the tracheal lumen in this Coyote may have reduced its stamina and prevented it from foraging efficiently. The esophageal lumen was

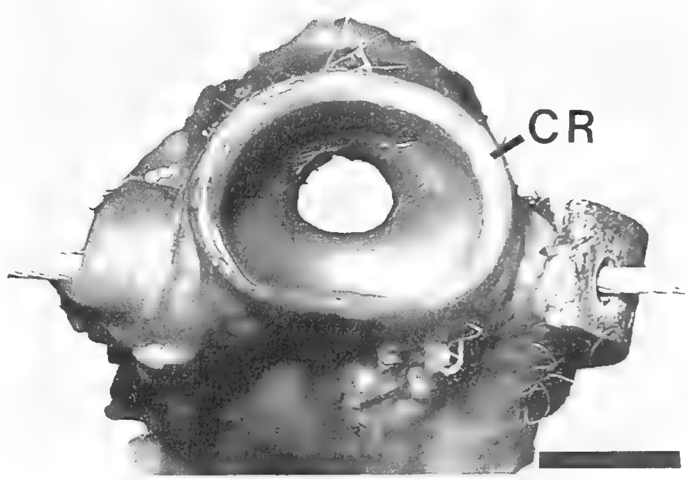

FIGURE 2. Cranial view of the trachea of a Coyote at the level where the cable of a snare has cut through this organ. The ventral side of the trachea is at the top. The cartilaginous ring (CR) outlines what should be the normal size of the tracheal lumen. Scar tissue of repair has greatly narrowed this lumen. (Bar = 1 cm.)

patent, but the presence of the cable against its ventral surface may have interfered with the passage of large food boluses. Albeit seemingly superficial, the suppurative process and, therefore, probable bacterial infection, associated with the soft tissue damage would have further drained the animal's energy reserves. Although this animal had not yet reached a stage of emaciation, its poor body condition, combined with the energy demands imposed by the winter season, may have been sufficient to bring it to a stage of exhaustion, perhaps combined with hypothermia. The clinical significance, if any, of the mild damage seen microscopically in the vagosympathetic trunks could have been assessed only in the live animal.

The efficacy of various trapping devices, including snares, can now be properly tested under standardized laboratory conditions (Proulx and Barrett 1990, 1991). Ultimately, however, the proportion of animals that fail to die rapidly and undergo prolonged suffering depends much on the experience and expertise of the trappers in the field. Regardless of the exact cause of failure of the snare in this case, its outcome emphasizes the need for continued attention to appropriate training of hunters and trappers, in order to ensure that the best trapping devices and capture techniques are used consistently and, as a result, as few animals as possible undergo undue suffering. It also illustrates the extreme resilience of Coyotes.

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Interactions of Brown Bears, *Ursus arctos*, and Gray Wolves, *Canis lupus*, at Katmai National Park and Preserve, Alaska

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We describe several encounters between Brown Bears (*Ursus arctos*) and Gray Wolves (*Canis lupus*) that were observed at Katmai National Park and Preserve in southwest Alaska. Katmai Brown Bears and Gray Wolves were observed interacting in a variety of behavioral modes that ranged from agonistic to tolerant. These observations provide additional insight regarding the behavioral plasticity associated with bear-wolf interactions.

Key Words: Brown Bear, *Ursus arctos,* Gray Wolf, *Canis lupus*, interactions, Katmai National Park and Preserve, Alaska.

Flexibility in mammalian behavior parallels the evolution of large brains (Gilbert 1989). Gittleman (1986) presented data showing that bears and wolves have the highest brain:body weight ratios within the order Carnivora, and claimed that this accounts for their behavioral plasticity. The context of the encounter setting, as well as the behavior of individual animals, likely influences the resulting relationship between bears and wolves at any given time.

Alaska Brown [Grizzly] Bears (*Ursus arctos*) and Gray Wolves (*Canis lupus*) are sympatric over much of their range and often compete for access to the same food resources (Adams et al. 1995). As sympatric, apical predators, bears and wolves probably interact frequently, although reports in the scientific literature are scant. The accounts reported illustrate the variable nature of Brown Bear – Gray Wolf interactions, and range from mutual tolerance (Lent 1964), to competitive (Adams et al. 1995; Hornbeck and Horejsi 1986; Ballard 1982), to predatory (Ballard 1980; Hayes and Mossop 1987). This note describes additional Brown Bear – Gray Wolf interactions observed at Katmai National Park and Preserve on the Alaska Peninsula, approximately 400 km southwest of Anchorage, Alaska.

Wolves harass bears

On 24 June 2001, while conducting Brown Bear research at Hallo Bay (154° 05' W, 58° 27' N) on the Katmai coast, the authors observed a pack of five wolves harass a pair of courting Brown Bears on the edge of extensive salt marsh meadows (*Carex* spp., *Plantago* spp., *Triglochin* spp.). Prior to this observation, we had repeatedly heard wolves "chorus howling" (Harrington and Asa 2003), and noted that the pack was gradually nearing our research field camp situated on the far end of the meadow. Anticipating their arrival, we positioned ourselves where we could observe them when they entered the meadow. Although it was late in the evening (2230 h Alaska Daylight Time), it was still light enough to see so we patiently waited while scanning the meadow. About 400 m south of our position, a pair of Brown Bears foraged on sedges in the meadow near a willow-alder (*Salix* spp., *Alnus* spp.) thicket. After we waited 10 minutes, the wolf pack suddenly appeared, emerging from the dense thicket about 25 m north of the two bears. The wolves trotted single file in the direction of the bears. Three of the five wolves had black-gray coats, similar in pattern to that of the German Shepherd (*C. domesticus*) breed of domestic dog; one wolf's coat was pure white; the other coal black. All five wolves appeared to be mature adults, standing nearly 1 m at the shoulder and similar in stature.

As one, the wolves circled south from the meadow's center toward the bears, which by then were focused on the wolves. The five wolves lined up, head-to-head, with the large male Brown Bear with < 2 m separating the lead wolf and the bear. Suddenly, one wolf rushed the male bear, which in turn lunged and swatted at the attacking wolf with its foreleg. Leaping forward, ducking the bear's defensive swat, then breaking away, the wolves took turns harassing the male bear. The bear responded to the attack with short lunges and aggressive paw swats while slowly backing away. About a minute into the confrontation, two wolves circled the bear and lunge-nipped at his unprotected hindquarters. In defense, the male bear swiftly spun around and swatted at the closest attacker, but the wolf dodged the bear's swinging paw then trotted a few meters away, tail wagging high. While the male bear counter-attacked the wolves formerly at his rear, the other three wolves, now at his unprotected hindquarters also began a nipping attack, to which the bear again whirled around, lunged, growled, and aggressively swatted at the wolves. The wolves easily outmaneuvered the large bear's paw swipes and lunges with quick, evasive maneuvers.

The wolves and male bear repeated this attack-counter attack interaction several times before a group of three wolves split from the pack and rushed the female bear that had been watching from a distance of about 10 meters, near the edge of the thicket. Repeating the same lunge, nip, and run strategy, the two groups of wolves attacked each bear, which rapidly spun around to defend themselves from the lunging-biting wolves. At this point, approximately 10-20 meters separated the two bears as they fended off the wolves. During these aggressive interactions, neither wolves nor bears were observed making physical contact, although the confrontation appeared quite serious. After 5 minutes of sustained confrontation, two wolves abruptly terminated their attack and began chasing each other in tight circles a short distance from the other wolves, wagging tails held high. Moments later, the remaining three wolves also withdrew, excitedly darted about, wagging tails, and then joined the others. After regrouping about 30 m from the bears, all wolves participated in a series of long, drawn-out "chorus" howls. From the forest to the west, responding howls (possibly from a single wolf) were heard in apparent reply. Moments later, the pack trotted southward into the rapidly dimming twilight, away from the bears and researchers. The entire interaction took approximately 20 minutes from the time the wolves were observed entering the meadow to when they disappeared into the dusk.

To the best of our knowledge, there had been no food source from which the wolves were attempting to drive the bears. It appeared to us that this wolf pack had encountered and approached these two bears and attempted to test, or harass, them for a short period before breaking off the encounter and moving on.

Wolves steal fish from bears

In mid-July 2001, a pair of Gray Wolves was observed stealing Chum Salmon (*Oncorhynchus keta)* from Brown Bears at Middle Creek where it empties into Hallo Bay on the Katmai coast. National Park Service (NPS) ranger Stephens Harper first saw the wolves when they trotted past the rangers' camp at 0830 h, heading to the nearby beach. Bears and wolves frequent the tidal flats because the stream channel is quite shallow at low tide, thus making salmon more vulnerable to predation. Harper walked to the stream mouth a few minutes before noon and observed two wolves and five single adult bears fishing in close proximity to one another.

Both wolves were gray with black highlights; one appeared mature, while the other was younger, lankier, and smaller (Figure 1). Fishing at the river mouth were five adult single bears. The younger wolf bedded on a gravel bar some distance from the bears while the other, much closer, visually scanned them, apparently waiting for one to catch a fish successfully. Once a bear caught a fish, the older wolf would move in, head low, and attempt to steal it by suddenly lunging and snagging a portion away from the bear. In response, the bear would protect its quarry by bolting and running after the wolf. Although there was a lot of chasing up and down the stream banks, the wolf easily outran and outmaneuvered these bears. This strategy worked, however, in getting bears to abandon what was left of the fish and the wolf would circle back around and eat these scraps. In turn, the older wolf would trot over to where the other was bedded, regurgitate a portion, and then head back to where the bears were fishing. During the entire hour that Harper watched, the wolf determinedly attempted to snatch fish from bears. Although these wolves attempted to catch salmon for themselves on several occasions, they were unsuccessful. One wolf, however, scavenged a Starry Flounder (*Platichthys stellatus)* lying on the beach that had been exposed at low tide.

Wolf displaces a bear from a moose carcass

In June 1997, an NPS employee observed a single wolf feeding on a Moose (*Alces alces*) carcass near a gravel pit adjacent to the Valley of Ten Thousand Smokes Road, approximately 13 km from Brooks Camp. Adjacent to the gravel pit is a wetland-pond complex impounded by a Beaver (*Castor canadensis*) dam. The following day, NPS employees Jim Gavin and Tom Ferguson observed a wolf and bear simultaneously at the site. The wolf was gray with black highlights, appeared mature, but thin. The bear was a young female, approximately 4 years of age. Initially, only the bear fed on the carcass while the bedded wolf watched from 40 m distant. After a while, the wolf moved in close and began harassing the bear by charging and biting at its hind legs. The wolf's constant attacks disrupted the bear's feeding as it defended itself. After 1.5 min of intense harassment, the bear took flight into the forest and the wolf usurped the carcass and started feeding. After approximately 10 min of feeding, the satiated wolf trotted off into the forest, reappeared 20 min later, then repeated the process several times, likely caching food (L. Adams, USGS research biologist, personal communication), or transporting it to young at a den nearby. Gavin observed the wolf feed in this manner for three consecutive days. On the third day, while the wolf was absent, the bear returned and resumed control of the Moose carcass. The wolf reappeared but did not approach any closer than 40 m to the feeding bear. Gavin did not observe the wolf attempt to displace the bear as before, although his observation sessions were only 30 min daily.

Bears and wolves fishing together

Chum Salmon enter freshwater to spawn in Hallo Bay's Middle Creek from early July through August. In 2001, Brown Bears and wolves were repeatedly observed fishing side-by-side (approximately 5 m apart) at this location with no apparent interactions or obvious concern toward the other species. Like bears, wolves sat patiently on the gravel bank and scanned the water for incoming salmon. Upon catching sight of an incom-

ing salmon, both bears and wolves would leap into the stream and attempt to capture it. Both bears and wolves appeared indifferent to one another, completely focused on fishing.

Similarly, in August 1992, NPS rangers B. Holmes and S. Klenzendorf observed a lone wolf and several bears fishing in close association for 2 h at Margo Creek (155° 03' W, 58° 29' N) in the western portion of Katmai National Park. At 1210 h on 13 August, an old female Brown Bear was fishing when a wolf appeared suddenly on the riverbank, watched the bear, and then sat down. The wolf was moderate in size and of gray coloration. The wolf wandered in the direction of the bear, entered the creek and retrieved a spawning Red Salmon (*Oncorhynchus nerka*). As the wolf fed, the bear wandered downstream towards the wolf. Consequently, the wolf abandoned its catch, moved quickly away, picked up another salmon, and then moved into the nearby White Spruce (*Picea glauca*) forest. At 1245 h, the wolf reappeared from the forest, plunged into the creek and emerged with a live salmon. Carrying the salmon in its mouth, the wolf disappeared again into the heavy cover of the forest. At 1255 h, the wolf reappeared and entered the creek in search of salmon. As the wolf waded about searching for fish, the same bear waded downstream until she and the wolf were about 20 m apart. In apparent response, the wolf abruptly ceased fishing, climbed out of the river and sat and watched the bear as it sought fish in that section of stream. Twenty minutes later, the wolf moved upstream and caught a salmon. As the wolf fed, a large adult male bear suddenly appeared thus causing the wolf to leave the area. The large male bear quickly caught a fish, then left the river, at which time the wolf reappeared. Moments later, the wolf caught a fish then reentered the forest. The observers left at 1402 h, impressed with the degree of tolerance the two species appeared to have for one another.

Wolf and bears traveling together

In June 1989, Aleska Szweda, an NPS employee stationed at Brooks Camp (155° 05' W, 58°33 ' N) in the western portion of Katmai National Park, observed a lone wolf traveling in the company of two Brown Bears. Szweda was driving along the park road, approximately 8 km from Brooks Camp, when she noticed what appeared to be two bears in the middle of the roadway, approximately 400 m ahead. The lumbering vehicle's approach prompted the bears to abandon the roadway suddenly, exposing a wolf that had apparently been in their immediate company (<2 m). The wolf too left the road, following the bears into the forest.

The following day, five park visitors reported seeing two bears and a wolf cross the Brooks River at a location known locally as the Oxbow. It was generally believed that these were the same three observed by Szweda the day previous along the park road, 8 km distant. The bears and wolf were clearly traveling as

FIGURE 1. Gray Wolf at Hallo Bay, Katmai National Park and Preserve, Alaska (Kent Fredriksson photograph).

a group as they worked their way down the riverbank, probed the riverbed for the shallowest crossing, and then emerged on the other side. It was reported that the trio fed together in an unusual manner; when the bears caught fish they fed only upon the brains and skin, leaving the rest for the wolf which, sitting immediately adjacent, would spring forward, snatch and eat the remainder. It is not unusual to see Red Foxes (*Vulpes vulpes*) or gulls (*Larus* spp.) attempting to snatch fish scraps from Brown Bears on salmon streams. But bears in these instances are far from cooperative, often lunging at the would-be thief, catching and killing them on occasion (T. Smith, personal observation). However, in this case, the bears tolerated the wolf's presence and, according to observers, did nothing to discourage its very close (1 m) proximity to them.

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Wild Turkey, *Meleagris gallopavo silvestris*, Behavior in Central Ontario During Winter

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Home range size, food habits, and roost site selection are described for the Eastern Wild Turkey (*Meleagris gallopavo silvestris*) introduced on the Precambrian Shield in central Ontario during the winters 1999 and 2000. Monthly home range size was correlated primarily to snow depth, although it was also likely associated to other factors, including food availability and/or roost site availability. Ferns and allies were used more than available, whereas monocots were used less than expected. Roost site-selection was primarily influenced by tree height. If the Eastern Wild Turkey is to expand its northern range in Ontario, winter food and roost site availability may be the primary determinants for successful introductions.

Key Words: Eastern Wild Turkey, *Meleagris gallopavo silvestris*, home range size, roost site, food availability, Ontario.

The Eastern Wild Turkey (*Meleagris gallopavo silvestris*) is a large, highly adaptable gallinaceous bird that is common throughout southern Ontario as a result of introductions in the last 20 years (Bellamy 2001). For northern turkey populations, winter is the most stressful season for satisfying energy demands (Oberlag et al. 1990). Variations in home range size and resource selection appear to be governed by snow depth (Porter et al. 1980; Vander Haegen et al. 1989) and, to a lesser extent, ambient temperature (Oberlag et al. 1990). Numerous accounts of turkey winter biology (e.g., Glover and Bailey 1949; Wunz and Hayden 1975; Porter et al. 1980; Kilpatrick et al. 1988; Vander Haegen et al. 1989), refer primarily to studies conducted in the United States. The winter biology of turkeys in these southern habitats may be different from that of birds living in Ontario due to inherent differences in climate and habitat. Hence, we report on home range size, food habits, and roost site use by Eastern Wild Turkeys introduced to the Precambrian Shield in central Ontario during the winters 1999 and 2000. It was hypothesized that turkey movement and forage availability were inversely related to snow depth. It was also hypothesized that the tallest trees provided optimum wild turkey roost sites due to their sturdiness.

Study Area

This study was conducted from November to March 1999/2000 and 2000/2001 near Noëlville, approximately 60 km southeast of Sudbury, Ontario (46°10'N, 80°25'W). The 169-km^2 study area was located within the Great Lakes–St. Lawrence Ecotonal Forest Region (Rowe 1972), characterized by flat to rolling topography, interrupted by rock outcrops and narrow valleys. The habitat consisted of 20% softwood forests, 37% hardwood forests, 28% abandoned pasture and hayfields, and 15% residential areas and rock outcrops. Beef farming was the dominant land use, with many fields cultivated for corn silage or pasture grasses. The forested areas were dominated by White Birch (*Betula papyrifera*) and Trembling Aspen (*Populus tremuloides*), interspersed with Balsam Fir (*Abies balsamea*), Eastern White and Red Pine (*Pinus strobus, P. resinosa*), Red Oak (*Quercus rubra*), White Spruce (*Picea glauca*), Red and Sugar Maple (*Acer rubrum, A. saccharum*), and Eastern Hemlock (*Tsuga canadensis*). Shrubs included raspberries (*Rubus* spp.), Bracken Fern (*Pteridium aquilinum*), blueberries (*Vaccinium* spp.), Beaked Hazel (*Corylus cornuta*), and asters (*Aster* spp.).

January, the coldest month of the year, had a mean temperature of –13.9°C and –10.5°C in 2000 and 2001, respectively. Total snowfall was 216.0 cm in 1999-2000 (10.0% below the 30-year norm) and 328.3 cm in 2000-2001 (22.2% above the 30-year norm). Snow depths exceeded 25 cm for 38 days in 1999-2000 and 111 days in 2000-2001.

Methods

Capture and Radio-Tracking

Wild Turkeys were captured with rocket nets (Hawkins et al. 1968) in southern Ontario and upper New York for introduction to the study area in February and March 1999 (10 males and 26 females) and March 2000 (13 females). Female turkeys were fitted with backpack-style, 32.5 g (1% of mean body mass), mortality-mode VHF radio-transmitters (Holohil Systems Ltd., Carp, Ontario). We tracked radio-fitted birds two to four days per week, or until battery failure, from 1999 to 2001. Locations of birds were determined by

triangulation using ≥ 3 locations (Heezen and Tester 1967) taken less than 15 minutes apart with a 2-element H antenna and portable receiver-scanner (Model STR-1000, Lotek Engineering Inc., Newmarket, Ontario). Average telemetry error was 156.9 m ± 21.1 SE (n = 40).

Home Range

Monthly home range sizes were calculated using the 100% minimum convex polygon method (White and Garrott 1990). All spatial analyses were conducted using an ArcView GIS software (Environmental Systems Research Institute, Redlands, California), with the Animal Movement Analysis (Hooge and Eichenlaub 1997) and Spatial Analyst Extensions.

Forage Selection

Active turkey feeding areas were identified by tracks, and forage plants were identified and collected. Crop contents from dead specimens provided a supplemental source of information. Forage species eaten were recorded regardless of the number of bites using a modified point-quarter method (Jost et al. 1999) during 2000-2001. Point samples of available plants adjacent to turkey tracks in the herb (less than 0.5 m) and shrub (0.5 to 2.0 m) layers were selected randomly and identified. Plants were grouped into five classes: (1) mosses, (2) ferns and allies, (3) conifers and allies, (4) monocots, and (5) dicots.

Roost Site

Roost sites were found by (1) observing commonly used trees, (2) finding turkey droppings under trees (Hoffman 1968), (3) examining areas where Wild Turkeys were common after snowfalls, or (4) locating radio-fitted birds on trees before sunset. Locations of roost sites were determined using a Global Positioning System (GARMIN International Inc., Olathe, Kansas). Equal numbers of random trees that may have provided potential roost sites within our study area were generated in ArcView GIS. Random trees were located using a Global Positioning System, and trees that had diameter at breast height (dbh) less than 10.2 cm were discarded (Kilpatrick et al. 1988).

Elevation, tree dbh, percent canopy cover, canopy density, distance to habitat edge, distance to open water, and tree height for actual and selected trees were measured. Elevation was measured with an altimeter, tree dbh with a diameter tape, percent canopy cover by averaging readings at each compass directions (N, S, W, E) using a convex spherical densiometer, canopy density by counting tree trunks of dbh ≥ 10.2 cm within 5 m of actual roost sites, and tree height from estimates on a subjectively selected "average" tree. Distances to habitat edge and open water were also determined by plotting roost sites on Ontario Base Maps (OBM) and Forest Resource Inventory (FRI) maps. The used habitat variables either had been previously described in the literature (Tzilkowski 1971; Kilpatrick et al. 1988; Chamberlain et al. 2000), or were hypothesized correlates based on the winter biology of the species.

Statistical Analyses

Data were pooled to maintain sufficient sample size, unless otherwise noted (Alldredge and Ratti 1986; Thomas and Taylor 1990). Home range sizes were compared between years using the Mann-Whitney *U*-test. Monthly home ranges were compared using the Kruskal Wallis test (Zar 1999). Two measurements used to examine the effects of winter on monthly home range size were (1) number of days with snow depths over 25 cm (Porter et al. 1980), and (2) number of days with minimum temperature less than –16.2°C (Oberlag et al. 1990). Spearman rank-order correlation analyses were used to compare mean monthly home range size with these two variables. The number of days with snow depth over 25 cm and the number of days with minimum temperature less than –16.2°C were also compared between years using the Mann-Whitney *U*-test.

Chi-square analysis was used to compare the frequencies of plants browsed by turkeys to availability (Neu et al. 1974). When forage selection differed, a Bonferroni *Z*-test was used to identify plants that were browsed more or less than availability (Byers et al. 1984). A series of one-way analyses of variance (ANOVA) was used to compare each habitat variable associated with roosting and random sites. Pearson correlation analyses were performed for the significant habitat variables. In order to minimize artifacts from environmental variations in habitat characteristics, an analysis of covariance (ANCOVA) was used to determine significant habitat variables. All analyses were conducted using Statistical Package for the Social Sciences (SPSS Inc., Chicago, Illinois) with significance level set at a = 0.10.

Results

Home Range

We obtained 441 locations from 12 radio-fitted turkeys from November 1999 to March 2000 and from November 2000 to January 2001. Mean winter home range size differed between years (U = 142.0, P = 0.002), as did monthly home range size (November: U = 9.0, P = 0.083; December: U = 8.0, P = 0.060; January: U = 3.0, P = 0.020). In addition, home range size differed among months in the two years (c^2 = 7.79, df = 4, P = 0.100; Table 1). Monthly home range size was correlated with the number of days with snow depth more than 25 cm (r_s = –0.71, n = 59, P = 0.050) and the number of days with minimum temperature less than –16.2°C (r_s = 0.75, n = 59, P = 0.031).

The number of days with snow depth over 25 cm differed (U = 4.0, P = 0.095) between 1999-2000 (9.60 ± 5.91 days, n = 5) and 2000-2001 (22.6 ± 4.88 days, n = 5), while the number of days with minimum temperature less than –16.2°C did not differ (U = 10.5, P = 0.690) between 1999-2000 (10.00 ±

TABLE 1. Winter home range size (ha) of Eastern Wild Turkey hens in Noëlville, near Sudbury, Ontario, 1999-2001 (SE = standard error of the mean).

	1999-2000			2000-2001			1999-2001 (Pooled Data)		
	n	Mean	SE	n	Mean	SE	n	Mean	SE
Winter	9	249	60	4	58	19	13	204	47
Monthly									
November	9	399	198	5	90	54	14	288	132
December	9	145	60	5	41	8	14	108	40
January	9	302	130	4	38	10	13	221	95
February	9	75	27	–	–	–	9	75	27
March	9	323	170	–	–	–	9	323	170

4.15 days, n = 5) and 2000-2001 (11.40 ± 3.63 days, n = 5). In 1999-2000, snow was generally packed or crusted with seeps and small streams remaining unfrozen. In 2000-2001, deep, powdery snow was common, and most seeps were frozen by mid-winter.

Forage Selection

Wild Turkeys foraged primarily on clovers (*Trifolium* spp.), asters (*Aster* spp.), goldenrods (*Solidago* spp.), and fertile fronds of the Sensitive Fern (*Onoclea sensibilis*) in the winter 1999-2000. Turkeys avoided species such as Cattail (*Typha latifolia*) and Meadow Sweet (*Spiraea latifolia*). Crops (n = 2) contained grass seeds and Sensitive Fern spore heads in late winter, confirming observations of turkeys feeding in the field. Ostrich Fern (*Matteuccia struthiopteris*), Trembling Aspen (*P. tremuloides*) buds, Corn (*Zea mays*), Smooth Wild Rose (*Rosa blanda*), and ragged moss (*Brachythecium* spp.) were other winter foods. Burdocks (*Arctium* spp.), Sensitive Fern, and Soybeans (*Glycine max*) comprised 21.4%, 23.0%, and 37.4% of the turkeys' diet, respectively, in 2000-2001.

Forages used by turkeys differed from availability (c^2 = 40.38, df = 4, $P < 0.0001$; Table 2). Mosses were used in proportion to availability while ferns and allies, including Bracken (*Pteridium aquilinum*) and Sensitive Ferns, were selected more than available. Conifer and allies, including Balsam Fir, Eastern White Pine, and White Spruce, were used in proportion to availability. Monocots, including Quackgrass (*Elymus repens*) and Timothy (*Phleum pratense*), were used less than available, while dicots, including ash (*Fraxinus* spp.), aster, Beaked Hazel, burdock, Choke Cherry (*Prunus virginiana*), Dogwood (*Cornus stolonifera*), Evening Primrose (*Oenothera biennis*), Fireweed (*Epilobium angustifolium*), goldenrod, Northern Wild Raisin (*Viburnum cassinoides*), raspberry (*Rubus* spp.), Soybean, Speckled Alder (*Alnus incana*), Swamp Thistle (*Cirsium muticum*), and willow (*Salix* spp.) were used in proportion to availability.

Roost Site Characteristics

Trembling Aspen, American Basswood (*Tilia americana*), Jack Pine (*Pinus banksiana*), Eastern White Pine, White Spruce, and Eastern White Cedar (*Thuja occidentalis*) were used as roost sites. Tree heights at roosting sites averaged 13.9 ± 0.8 m, and were higher than the tree heights (8.8 ± 0.7 m) measured at random sites ($F_{1,22}$ = 20.98, P = 0.0001; Table 3). Mean dbh of trees associated with roost sites, 37.7 ± 3.0 cm, was significantly larger ($F_{1,22}$ = 15.69, P = 0.0007) than tree dbhs on random sites (24.1 ± 1.7 cm). Roost site topographical elevations averaged 217.1 ± 7.1 m and were significantly higher ($F_{1,22}$ = 4.49, P = 0.0455) than the 188.8 ± 11.3 m measured at random sites. Canopy cover (73.3 ± 8.8%), tree density (849.3 ± 127.7

TABLE 2. Chi-square analysis and Bonferroni Confidence Intervals for winter ground forage used by Eastern Wild Turkeys during winter in Noëlville, near Sudbury, Ontario (χ^2 = 40.38, df = 4, $P < 0.0001$).

Forage Class	Forage Selected	Forage Available	Proportion Selected	Proportion Available	90% Confidence Interval on Proportion
Mosses	0.1	1.0	0.001	0.004	0.000-0.006[b]
Ferns and allies	43.0	32.0	0.230	0.124	0.158-0.302[c]
Conifers and allies	5.0	4.0	0.027	0.016	0.000-0.055[b]
Monocots	0.1	13.0	0.001	0.050	0.000-0.006[a]
Dicots	139.0	208.0	0.743	0.806	0.669-0.817[b]
Total	187.2	258.0			

[a]Proportions greater than the upper confidence limit indicates use less than available.
[b]Proportions within the confidence limit indicates use equal to availability.
[c]Proportions less than the lower confidence limit indicates selection greater than available.

TABLE 3. Comparison of physiographic characteristics of Eastern Wild Turkey roost (n = 12) and random (n = 12) sites in Noëlville, near Sudbury, Ontario.

	Roost sites		Random sites			
Habitat characteristic	Mean	SE	Mean	SE	F	P
Height (m)	13.9	0.8	8.8	0.7	20.98	0.0001
Tree dbh (cm)	37.7	3.0	24.1	1.7	15.69	0.0007
Canopy coverage (%)	73.3	8.8	70.4	9.7	0.05	0.8303
Density (trees/ha)	849.3	127.7	764.3	110.9	0.25	0.6206
Elevation (m)	217.1	7.1	188.8	11.3	4.49	0.0455
Distance to habitat edge (m)	97.5	21.1	64.8	17.7	1.42	0.2468
Distance to open water (m)	73.5	18.6	122.1	34.7	1.52	0.2303

trees/ha), distance to clearing (97.5 ± 21.1 m), and distance to open water (73.5 ± 18.6 m) of roost trees did not differ (all $P > 0.10$) from those at random sites.

Height of roost site was correlated with tree dbh ($r = 0.78$, n = 24, $P = 0.003$). There was no correlation between elevation and tree dbh ($r = -0.36$, n = 24, $P = 0.245$) nor elevation and tree height ($r = 0.04$, n = 24, $P = 0.900$). Tree height was primarily responsible for the differences between roosting and random sites, regardless of the covariate tree dbh ($F_{1, 21} = 3.45$, $P = 0.077$). Tree dbh did not differ between roosting and random sites once the covariate height was statistically controlled ($F_{1, 21} = 15.87$, $P = 0.513$).

Discussion

Winter mean home range sizes for turkeys released in northern Ontario (204 ± 47 ha) were similar to those of turkeys introduced to Indiana (Miller et al. 1985), and Iowa (Little and Varland 1981), but exceeded those reported in Ohio (Clark 1985) and in southern Ontario (Weaver 1989). Although previous studies reported a decline in monthly home range size between November to March (Porter 1977; Miller et al. 1985), this pattern was not observed in 1999-2000. This suggested that movement in late winter (1999-2000) was not limited by snow depth. On several occasions when snow covered local food resources, birds increased flight distance to otherwise unused parts of the home range. Snow depth was inversely related to winter and monthly home range size, confirming data from previous studies in Minnesota (Porter 1977), Indiana (Miller et al. 1985), Pennsylvania (Wunz and Hayden 1975), and southern Ontario (Weaver 1989).

Glover and Bailey (1949) described the Wild Turkey as a nomadic feeder with a tendency to sample a wide variety of forages, primarily dictated by their availability. The heavy use of ferns and allies was almost exclusively due to the selection of fertile fronds of the Sensitive Fern found in lowland hardwood sites and along seeps. Decker et al. (1991) reported that Sensitive Ferns were foraged in large quantities by Wild Turkeys because of their high nutritional content (crude protein 18.6%) and/or the high availability of this food in concentrated, relatively snow-free patches. Vander Haegen et al. (1989) reported that fields spread with manure were also important sources of winter food in Massachusetts, but the value of manure to wintering turkeys in central Ontario was questionable, as emaciated birds were observed to ignore manure piles. Glover and Bailey (1949) reported wariness by turkeys of supplemental feeding sites with corn and oats in West Virginia when natural forage (e.g., wild grape, *Vitis* spp.) was absent.

Standing crops, such as Soybean or clover, provided nutritious food in moderate snow conditions during early winter. Soybeans contain protein, but also produce trypsin inhibitors, which lower digestibility and fat absorption (McNaughton and Reece 1980, *in* Loesch and Kaminski 1989). Post-mortems in winter 2000-2001 (n = 5) verified that emaciated turkeys were under severe nutritional stress, and had catabolized significant amounts of muscle tissue.

Forages that were present in the study area, but may have been underestimated in use, included conifer and hardwood trees. Although primarily ground feeders, Eastern Wild Turkeys are capable of flight, but forage obtained in the tree-canopy layer is difficult to systematically record. Turkeys were observed feeding on Trembling Aspen buds on several occasions; however, the results indicate that prolonged periods of deep snow severely limited food availability for Wild Turkeys in northern Ontario.

Roosting sites of turkeys were the tallest and largest trees, usually conifers, which were found at higher elevations. Conifers may reduce wind speed and heat loss (Kilpatrick et al. 1988). Tzilkowski (1971) found that turkey winter roosts were dominated by large deciduous trees in Pennsylvania, suggesting that tree height and sturdiness were important factors. However, Chamberlain et al. (2000) suggested that turkeys roost in the nearest suitable habitat at the end of the day. Although roost sites were closer to open water than random sites, this proximity appeared to be due to forage availability. Turkeys used snow to meet winter water requirements in this study. Exum et al. (1985) argued against Wild Turkey dependence on open water in southern Ala-

bama during spring and summer; however, Kilpatrick et al. (1988) suggested that winter foods in Rhode Island were too low in water content to meet the species' needs. Roosting sites may have been closer to water because of the accelerated growth of trees associated with moist environments (Kilpatrick et al. 1988).

The results of this study suggest that (1) winter food and roost site availability are the primary factors determining successful turkey introductions in northern Ontario, (2) stands of Soybean or Corn are not sufficient to support Wild Turkey populations unless natural foods are available, and (3) snow depth is an important parameter influencing successful reintroduction of this species on the Precambrian Shield.

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Fifteenth Census of Seabird Populations in the Sanctuaries of the North Shore of the Gulf of St. Lawrence, 1998-1999

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Rail, Jean-François, and Gilles Chapdelaine. 2004. Fifteenth census of seabird populations in the sanctuaries of the North Shore of the Gulf of St. Lawrence, 1998-1999. Canadian Field-Naturalist 118(2): 256-263.

For the first time since the tradition began in 1925, the quinquennial census of seabirds in the Migratory Bird Sanctuaries of the North Shore of the Gulf of St. Lawrence was divided between two years in 1998-1999. Trends between 1993 and 1998-1999 were variable across species and sanctuaries. In particular, following the large decreases in both species noted in 1993, the 1998-1999 survey showed that Black-legged Kittiwakes had declined further, while the number of Herring Gulls had stabilized. Alcids were all doing well except for the Atlantic Puffin which showed severe yet unexplained drops at all major colonies. Law enforcement efforts appear reflected in seabird population trends, as well-patrolled sanctuaries such as St. Mary's Islands seem to do well, whereas many species at the Baie des Loups and Île à la Brume sanctuaries are far from their historical levels. In addition to a better law enforcement program, research is needed in order to identify other conservation problems that some species may be facing.

Pour la première fois depuis 1925, l'inventaire quinquennal des oiseaux marins des refuges d'oiseaux migrateurs de la Côte-Nord du Golfe Saint-Laurent fut mené sur deux ans, soit en 1998 et 1999. Les tendances des populations entre 1993 et 1998-1999 étaient variables selon l'espèce et le refuge. En particulier, suite à une décroissance notée chez les deux espèces en 1993, l'inventaire de 1998-1999 a démontré que la Mouette tridactyle avait encore diminué, tandis que le nombre de Goélands argentés s'était stabilisé. Les populations d'Alcidés ont toutes semblé en bonne santé sauf celle du Macareux moine dont les colonies importantes ont diminué de façon sévère et inexpliquée. Les efforts de protection par l'application de la loi se reflètent visiblement dans les tendances des populations d'oiseaux de mer, puisque les refuges les mieux surveillés comme celui des Îles Sainte-Marie vont bien, alors que plusieurs espèces aux refuges de Baie des Loups et de l'île à la Brume sont loin de leurs niveaux historiques. En plus d'un meilleur programme d'application de la loi, la recherche est nécessaire pour identifier les autres problèmes de conservation auxquels certaines espèces font face.

Key Words: Seabirds, populations, sanctuaries, Gulf of St. Lawrence, Atlantic Puffin, larids, alcids.

Apart from its major use in providing updated information on seabird numbers and distribution throughout the migratory bird sanctuaries on the North Shore of the Gulf of St. Lawrence (Figure 1), another major application of the results of this traditional survey is in identifying trends. Follow-up censuses have been carried out fairly regularly since the first census in 1925 (Lewis 1925, 1931, 1937, 1942; Hewitt 1950; Tener 1951; Lemieux 1956; Moisan 1962; Moisan and Fyfe 1967; Nettleship and Lock 1973; Chapdelaine 1980, 1995; Chapdelaine and Brousseau 1984, 1991), providing the trends over a period of approximately 75 years, including the present survey. This survey also provides one of the ways we monitor the broader marine environment. In effect, these wide-ranging birds are acting as our sampling agents. As human impact on the seas increases, whether directly by exploitation of resources or marine pollution, or less directly by factors such as global warming, early indications of changes are vital. Clearly any changes in the size of seabird breeding colonies are of major importance to conservationists to orient any concrete action to be taken or to seabird biologists to learn more about the regulation of seabird numbers and the wide range of factors known to influence the birds.

This article presents the current status of the 15 marine bird species breeding in the sanctuaries in 1998-1999, and compares them with those of the 1993 census. Scientific names are given in Table 1.

Methods

The census of seabirds in the sanctuaries of the North Shore of the Gulf of St. Lawrence was conducted over two years. All of the technical details of this census (methods, estimates calculations, mapping of the colonies, weather conditions) are discussed in Rail and Chapdelaine (2002) and summarized below for each family of birds.

GAVIIDS – We counted all Red-throated Loon nests by systematically walking around the ponds on the islands of each sanctuary. In a few exceptional cases we noted the presence of adults instead of landing on the island.

HYDROBATIDS – We conducted a systematic count of active burrows. A burrow was considered active if we were able to reach an adult inside, or detect signs of recent occupation (soil freshly excavated or oily odour characteristic of petrels at the entrance of the burrow).

ANATIDS – On Corossol Island, we used a system of quadrats from which we extrapolated and average density (nests/ha) for the entire area deemed suitable

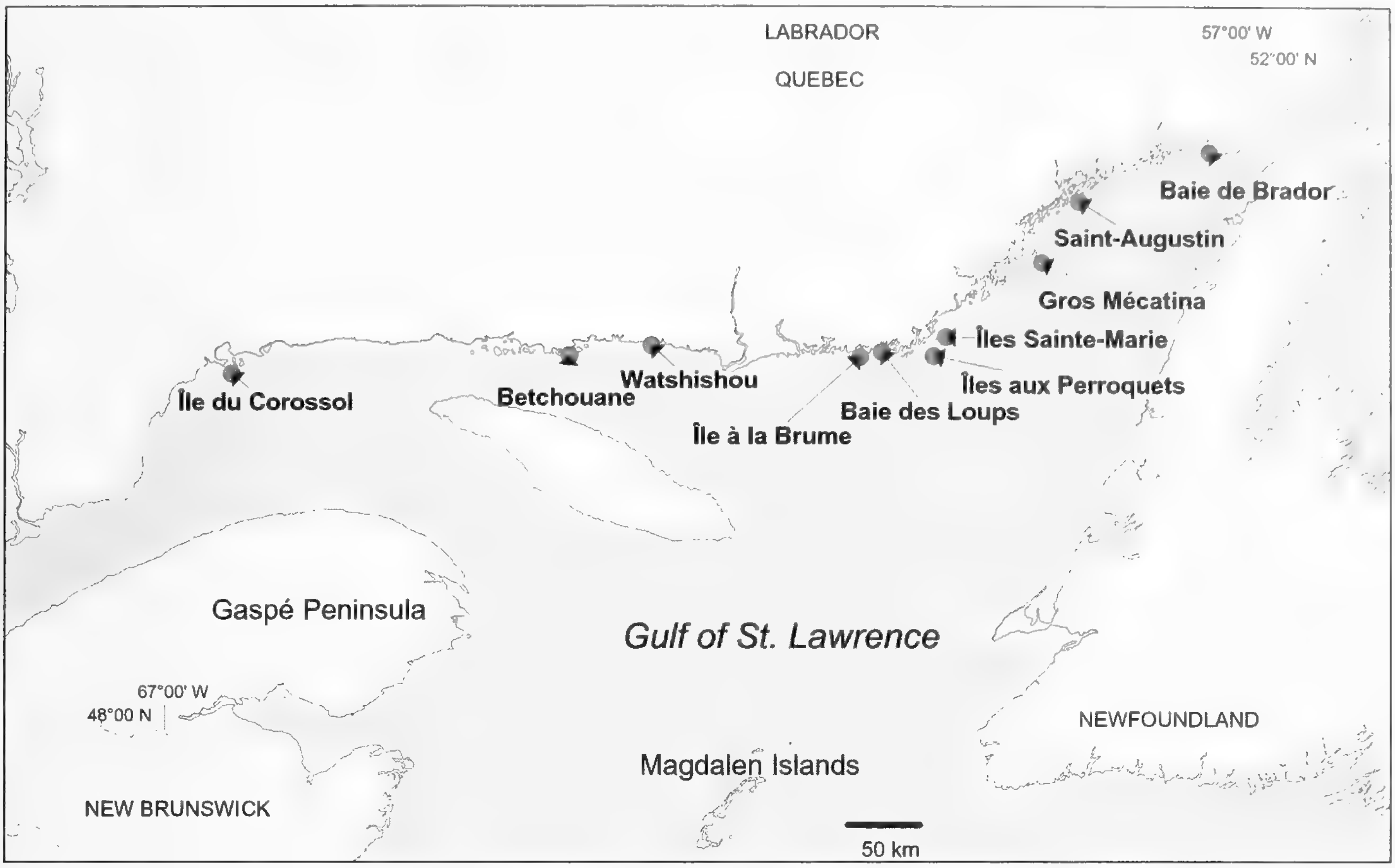

FIGURE 1. Location of the sanctuaries of the North Shore of the Gulf of St. Lawrence.

for Common Eiders (Chapdelaine 1978*). In the Betchouane Bird Sanctuary, we conducted a systematic nest count on Calculot Island, and (as in preceding censuses) used a system of line-transects of varying length on Innu Island (*see* Caughley 1977). In sanctuaries featuring many islands (e.g., Watshishou, île à la Brume, Baie des Loups), we counted all the nests on at least 27% of the land area and extrapolated an average density over the entire area of all the islands. On the Îles aux Perroquets and Îles Sainte-Marie sanctuaries, extrapolation was done after systematic counts were made on most large islands, covering 57% and 98% of total land area, respectively (*but see* Rail and Chapdelaine 2002 *for details*).

PHALACROCORACIDS – Systematic counts of all Great and Double-crested Cormorant nests were carried out. At the Corossol Island colony, Double-crested Cormorant nests in treetops were counted from an elevated lookout point.

LARIDS – In the large Herring Gull colony of Corossol Island, we sampled sub-colonies where the number of nests (Np) and the number of adults (Ni) were determined. Then, using the factor k (k=Np/Ni), we estimated the number of pairs in sectors where we counted only the number of adults present. In the Betchouane Sanctuary, all gull nests were counted systematically, and were attributed to Herring and Great Black-backed gulls according to the observed proportions of adults of both species. In the other sanctuaries all larids were censused with a combination of nest counts and adult counts. Proportions of Arctic and Common terns in mixed tern colonies were not always determined, so the results for the two species are combined in Table 1. All Black-legged Kittiwake nests attended by adults were counted.

ALCIDS – We carried out systematic counts of eggs and active burrows in colonies of Atlantic Puffins, Razorbills and Common Murres that could be accessed with minimal disturbance. Elsewhere we counted individuals at the colony and on adjacent waters from a distance. All colonies with large numbers of Common Murres were carefully avoided because of their sensitivity to disturbance. In particular, at the Îles Sainte-Marie Sanctuary, where 87% of breeding Common Murres on the North Shore are found, 98% of the population estimate for the Common Murre results from adult counts. For Atlantic Puffins nesting on the Blacklands Island in the Baie des Loups Sanctuary, we used the factor k method described above for larids. On Île aux Perroquets in the Baie de Brador Sanctuary, we used evenly spaced grids and line transects to delimit the area of both the puffin and Razorbill colonies, evaluate mean nest densities, and then extrapolated the populations (*see* Nettleship 1973* ; Chapdelaine 1978*). The Black Guillemot population was estimated from adult bird counts around the islands, although exceptionally we recorded a pair when a nest was found with no adult in sight.

TABLE 1. Census of seabirds (number of individuals) in the bird sanctuaries of the North Shore of the Gulf of St. Lawrence 1993 and 1998-99.

	Île du Corossol		Betchouane		Watshishou		Île à la Brume		Baie des Loups		Îles aux Perroquets		Îles Sainte-Marie		Gros Mécatina		Baie de Brador		Total	
Species	1993	1998	1993	1998	1993	1998	1993	1999	1993	1999	1993	1999	1993	1999	1993	1999	1993	1999	1993	1998-99
Red-throated Loon																				
Gavia stellata							2	2	10	12	10	24	44	42	-	2			66	82
Leach's Storm Petrel																				
Oceanodroma leucorhoa	1614	718							226						-				1840	718
Great Cormorant																				
Phalacrocorax carbo												14	78	326	-	2			78	342
Double-crested Cormorant																				
Phalacrocorax auritus	1278	950			714	1078							1480	802	-				3472	2830
Common Eider																				
Somateria mollissima	1010	1162	4872	3088	4444	4754	1072	916	1392	2090	560	484	1198	578	-				14548	13072
Ring-billed Gull																				
Larus delawarensis						443	28	41	76						-				104	484
Herring Gull																				
Larus argentatus	1224	1968	1006	950	964	831	164	202	404	391	174	187	860	342	-	59	83	58	4879	4988
Great Black-backed Gull																				
Larus marinus	662	1160	112	122	338	185	28	22	320	206	96	95	518	385	-	46	210	206	2284	2427
Black-legged Kittiwake																				
Rissa tridactyla	5898	3384	144	170							120	22	132	182	-	40		58	6294	3856
Caspian Tern																				
Sterna caspia															-				0	0
Common and Arctic Terns																				
Sterna hirundo																				
Sterna paradisaea					260	38	113	46	34	32	72	65	66	96	-	100		17	545	394
Common Murre																				
Uria aalge	280	316							8	32	5233	3593	25308	26156	-	13		14	30829	30124
Razorbill																				
Alca torda	589	815	142	244		8	8	8	241	990	3113	2046	3342	7220	-	388	954	2622	8389	14341
Black Guillemot																				
Cepphus grylle	99	223			13	43	74	30	75	64	47	124	101	167	-	137	2		411	788
Atlantic Puffin																				
Fratercula arctica		3	276	324					13834	8318	3354	1585	5650	3020	-	103	23570	15780	46684	29133
Total	12654	10699	6552	4898	6733	7380	1489	1267	16620	12135	12779	8239	38777	39316	-	890	24819	18755	120423	103579

TABLE 2. Changes in the numbers of seabirds in sanctuaries on the North Shore of the Gulf of St Lawrence, Québec, 1988 to 1998-1999.

	Years of survey			Compound annual growth* rate by period	
Species	1988	1993	1998-1999	1988-1993	1993-1998**
Red-throated Loon	76	66	80	-2.82%	3.21%
Leach's Storm-Petrel	1744	1840	718	1.07%	-18.78%
Great Cormorant	86	78	340	-1.95%	24.54%
Double-crested Cormorant	4558	3472	2830	-5.44%	-3.49%
Common Eider	8536	14548	13072	10.66%	-2.10%
Ring-billed Gull	288	104	484	-20.37%	31.04%
Herring Gull	16195	4879	4929	-24.00%	0.49%
Great Black-backed Gull	1883	2284	2381	3.86%	1.15%
Black-legged Kittiwake	8536	6294	3816	-6.09%	-10.02%
Caspian Tern	15	0	0	-100.00%	-
Common and Arctic Terns	1350	545	294	-18.14%	-12.03%
Common Murre	26049	30829	30111	3.37%	-0.39%
Razorbill	7036	8389	13953	3.52%	8.58%
Black Guillemot	521	411	651	-4.74%	8.70 %
Atlantic Puffin	35142	46684	29030	5.68%	-7.92%

$$*r = \frac{\log_e N(t) - \log_e N(o)}{t} \; 100\%$$

** Populations in sanctuaries censused in 1999 were back-calculated to 1998 to get the compound annual growth rate for all North Shore sanctuaries after 5 years

Results

In the eight sanctuaries censused in 1993 and 1998-1999 (Gros Mecatina excluded), the total number of birds had decreased by 15% or 17 734 individuals (see Table 1 for details). This is mostly due to the dramatic 38% decline of the Atlantic Puffin (-17 654 individuals), which was by far the most abundant seabird in the North Shore sanctuaries in 1993 (but was outnumbered by the Common Murre in 1999). Leach's Storm-Petrels, Black-legged Kittiwakes and Common and Arctic Terns also declined at a very rapid rate between 1993 and 1998-1999 (Table 2). Double-crested Cormorants numbers also diminished. The Razorbill is the only abundant species showing a large increase, with the 1998-1999 population estimate exceeding by 5564 individuals the result of 1993 (+66%). This species has made a spectacular comeback since 1972, when less than 3000 individuals were recorded in the sanctuaries (compared to 14 341 in 1998-1999). The small populations of Great Cormorants, Ring-billed Gulls and Black Guillemots also grew rapidly between 1993 and 1998-1999, as did Red-throated Loons but more slowly. In four species, numbers appeared rather stabilized, the Common Eider and Herring Gull after having showed very sharp trends between 1988 and 1993 (annual growth rates of +11% and -24%, respectively), the Great Black-backed Gull and Common Murre following less striking but significant rises (annual growth rate of +3.9 and +3.4%, respectively). Finally, no Caspian Terns were found for the second quinquennial census in a row.

We visited the Corossol Island Sanctuary on 30 and 31 May 1998. Major increases in large gulls (Herring and Great Black-backed gulls) were noted. Populations of alcids also expanded, and in particular the number of Black Guillemots more than doubled compared to 1993. Puffins were recorded for the first time during quinquennial censuses, bringing up to 10 the number of seabird species breeding there. The Common Eider was also more abundant. On the other hand, the colony of Leach's Storm-Petrels was reduced to less than half between 1993 and 1998, and Black-legged Kittiwakes also declined quite rapidly. Double-crested Cormorants were down 25%, and colony localization had seemed to change a bit, possibly prompted by forest decay caused by their long-term occupation (nests are in treetops of conifers) in some areas.

On 2 and 3 June 1998, we visited the Betchouane Bird Sanctuary. The most important change in the seabird community was the 36% decrease in Common Eider, by far the most abundant bird there. The Razorbill apparently continued its spectacular comeback, with a 72% population increase between 1993 and 1998. Herring Gulls, Great Black-backed Gulls, Black-legged Kittiwakes and Atlantic Puffins were almost stable or slightly increasing.

After a tremendous population explosion following 1982, the population growth of the Common Eider in Watshishou appeared to have slowed down considerably between 1993 and 1998. The Black Guillemot population increased threefold during the same period. Double-crested Cormorant and Great Black-backed Gull numbers showed opposite trends; the former species underwent a 50% increase whereas the latter was reduced by half. Herring Gull population size appeared slightly reduced compared to 1993, but the 1998 result was by far the highest for the species in Watshishou, except for 1993. The 1998 survey confirmed a catastrophic (-96%) and inexplicable decline of terns in Watshishou since 1988. In the past, this sanctuary, consisting of more than 200 islands, always had a fair number of terns (range 128 – 1490 individuals), and was the most important sanctuary on the North Shore in that regard. In 1998, however, despite better coverage (more islands were visited than in previous censuses), we found only 19 breeding pairs distributed in 5 very small colonies. The Watshishou Bird Sanctuary was visited on 6, 7 and 8 June 1998.

The following year (in 1999), seabirds were censused on 14 June at the Île à la Brume Sanctuary. The Common Eider had decreased slightly since 1993, but was still relatively abundant. Population trends were up for Herring and Ring-billed gulls; however numbers of these two species are rather small and tended to vary a lot in the past. The number of Great Black-backed Gulls dropped further between 1993 and 1999, reaching its lowest level ever in 1999. Terns declined sharply during the same period, and in fact since 1988 their population trends at the Île à la Brume (-84%) and Watshishou sanctuaries are similar. Status of the very small populations of Red-throated Loon and Razorbill are still precarious, as their numbers remained stable between 1993 and 1999 at two and eight individuals, respectively. Finally, no Caspian Terns were found for the second quinquennial census in a row at Île à la Brume, the only traditional breeding site for this species in the Province of Québec.

We visited the Baie des Loups Bird Sanctuary on 18 June. The most abundant bird there, the Atlantic Puffin, had declined by 40% since 1993. The Great Black-backed Gull population also decreased noticeably (36%). Breeding Leach's Storm-Petrels apparently deserted the sanctuary, which leaves the Corossol Island Sanctuary as the only active breeding site of that species on the North Shore, and maybe in the whole province. On the brighter side, the Common Eider population increased by 50%. Also, the Common Murre and the Razorbill, once abundant in the sanctuary but which had declined steadily up to the very low and worrying levels observed in 1993, bounced back and increased threefold between 1993 and 1999. Red-throated Loon, Herring Gull, terns, and Black Guillemot numbers remained fairly stable.

The Îles aux Perroquets Bird Sanctuary was visited on 11 and 21 June 1999. The population of Atlantic Puffin showed a similar drop (-53%) as in the other large colonies on the North Shore. In contrast to the general upward trend observed in these species at the other sanctuaries, a decrease in Common Murres and Razorbills was noted at the Îles aux Perroquets Bird Sanctuary in 1999. The number of Common Eiders declined only slightly. Except for the Black-legged Kittiwakes whose population collapsed (-82%) between 1993 and 1999, numbers of larids were quite stable. With only 11 nests found in 1999, the kittiwake may well disappear as a breeding species at the Îles aux Perroquets in the future. On the positive side, the two smallest seabird populations breeding in the sanctuary in 1993, those of the Red-throated Loon and Black Guillemot, both showed large increases (140% and 164%, respectively). Also worthy of notice is the addition of the Great Cormorant as a breeding species in the sanctuary.

The Îles Sainte-Marie Bird Sanctuary (visited on 10, 11, 13, 17 and 19 June) was again found to have the highest seabird diversity (12 breeding species) and abundance (total of 39 316 individuals). Common Murres represented two-thirds of the seabird population with an estimated 26 156 breeding birds. The number of murres appeared quite stable between 1993 and 1999, after the spectacular and steady recovery of the species following 1972 (when only 4120 birds were counted). Razorbills show the same long-term trend as murres, but were still going up in 1999 (116% rise compared to 1993). The Great Cormorant colony expanded unexpectedly (+318%) to become the largest of this species on the North Shore. Increases were noted in Black-legged Kittiwakes, Black Guillemots and terns as well. Numbers of Double-crested Cormorants, Common Eiders, and Atlantic Puffins were reduced roughly by half. Herring Gulls were again found to be declining very sharply, whereas Great Black-backed Gulls showed a moderate decrease. Finally, the number of Red-throated Loons in 1999 was only one pair short of the highest counts which were recorded on the two preceding censuses.

A little farther to the east, a few small offshore islands constitute the Gros Mécatina Bird Sanctuary, which was created in 1996. On 23 June 1999, the sanctuary was included for the first time in a quinquennial census. Species diversity was impressive for such a small sanctuary, as nine seabird species were found breeding. Numbers of each species were low though, and the most abundant species was the Razorbill with 388 birds observed. According to naturalists such as Coues (1862), these islands were once inhabited by tens of thousands of Common Murres, so the sanctuary has definite potential for seabird conservation if it is well protected.

The Baie de Brador Bird Sanctuary is well-known for its colonies of Atlantic Puffin and Razorbill. On 28 and 29 June 1999 however, we were quite surprised to discover the addition of Black-legged Kittiwakes and terns breeding there for the first time, as well as Common Murres which had not bred there since 1965. Herring Gulls and Great Black-backed Gulls seemed well established as breeders for the second census in a row (they were present in very small numbers or absent prior to 1993). Also, as in most other sanctuaries, Razorbill numbers grew very fast between 1993 and 1999 (+175%). Nevertheless, all these results were darkened by the finding that Atlantic Puffins had declined by a third since 1993, when the population seemed on its way to get back to historic levels. Because it has always been the stronghold of puffins in our province, the Baie de Brador Bird Sanctuary plays a leading role in the conservation of the species in Québec.

Discussion

Total number of seabirds recorded in 1998-1999 in the North Shore Bird Sanctuaries dropped 15% (or 17 734 birds, Gros Mécatina excluded). But most of this decrease could be attributed to the Atlantic Puffin whose 38% decline represent a loss of 17 551 birds. Population trends in other species were variable, as four species increased rapidly, four species decreased at a fast rate, and the others showed more stable or moderate trends. Numbers of Razorbills and Black Guillemots increased at a very rapid rate in almost every sanctuary (where they are present). The only Great Cormorant colony recorded during the 1993 census was found at the Îles Sainte-Marie Bird Sanctuary; by 1999, that colony had grown so much that immigration must be partly involved. Also, three new colonies of this species were found elsewhere in the sanctuaries in 1999. The Ring-billed Gull is the last seabird species which increased at a very fast rate since 1993. However, this species is poorly represented in the North Shore Bird Sanctuaries, where their numbers always fluctuated widely in the past. Instead of suggesting a real population trend, our results may rather reflect colony displacements as the species exhibits poor site fidelity on the North Shore.

The Atlantic Puffin was not the only species showing a sharp decline between the last two censuses of the North Shore sanctuaries. The case of the Leach's Storm-Petrel is equally worrying; the species was found breeding in four sanctuaries in 1988, but in 1998-1999 only the Corossol Island colony was still active, and its number of nests was reduced to less than half compared to 1993. Moreover, this may be the only Leach's Storm-Petrel colony left in the whole province. Thus the status of the species appears precarious in Québec. The Black-legged Kittiwake was found breeding in six sanctuaries in 1998-1999, whereas in the past it had been breeding in no more than four sanctuaries. However, over 90% of the kittiwakes in the sanctuaries are concentrated at the Corossol Island colony, where a 39% drop was observed between 1993 and 1998. In fact the colony decreased by 55% since 1988 and the trend was even faster in the last five years. Observations made on diet and breeding success of larids at Corossol Island in 1996-1998 showed that kittiwake breeding success was severely affected by Herring Gull predation on large chicks, especially when capelin appeared less available. The poor kittiwake productivity measured in 1997-1998 (0.60 and 0.27 young fledged per pair, respectively) means that recruitment is likely not enough to compensate for natural mortality, so that further decline of the colony is expected. Terns, after the fashion of Ring-billed Gulls, are poorly represented in the sanctuaries and their population trends partly reflect the unpredictability of their breeding activities. However, their numbers dropped severely for a second quinquennial census in a row, resulting in a 80% decline since 1988. The case of the Watshishou Bird Sanctuary, which has always been the most important for terns, is particularly intriguing as that tern population reached an unprecedented low level in 1998.

Among species with near-stable population trends between 1993 and 1998-1999 are the Common Eider and the Common Murre, two species whose numbers finally appeared to level off after spectacular increases were noted in each of the four preceding censuses. Herring Gull population trends on the North Shore (and especially at Corossol Island) have been correlated with cod fishery, an industry that provided significant amounts of fish offal available to gulls (Chapdelaine and Rail 1997). After a boom in the early 1980s, cod fishery and Herring Gull populations collapsed concurrently in the late 1980s-early 1990s. But in 1998-1999 it seemed that after a drastic (-78%) decline between 1988 and 1993, the Herring Gull population was stabilized, perhaps to a more "natural" level. The number of Red-throated Loons increased only slightly between the last two surveys, yet the 1998-1999 total (82 individuals) is the highest ever recorded in the sanctuaries. The Double-crested Cormorant population declined but only at a slow rate after 1993, and in 1998-1999 the total population estimate for the sanctuaries was still the third highest since 1925. The steady rise of Great Black-backed Gull numbers continued to slow down to be nearly stable between 1993 and 1998. Finally, the Caspian Tern did not breed in 1993 and 1999 at the Île à la Brume Sanctuary, where it consistently nested between 1925 and 1988. The more time passes by, the more unlikely this species will be back, unless appropriate measures are taken to prevent disturbance of the only breeding site of Caspian Terns in Québec.

While some population trends varied regionally, others suggest large-scale factors are involved. In particular, Black-legged Kittiwake and Herring Gull declines since the end of the 1980s are reported not only

in North Shore sanctuaries, but also at all large colonies around the Gaspé Peninsula and at the Magdalen Islands (Chapdelaine et al. 2003*). Atlantic Puffin numbers dropped at all major North Shore concentrations between 1993 and 1999. On the other hand, Razorbill colonies continued to expand everywhere in the Gulf and in the Estuary (Chapdelaine et al. 2001), and the small populations of Great Cormorant on the North Shore and around the Gaspé Peninsula grew significantly since 1988-1990. So far we have presented some evidence that the Herring Gull population had been influenced by cod fishery activities (Chapdelaine and Rail 1997), and that an abundance of small fish such as sandlance (*Ammodytes* sp.) and Capelin (*Mallotus villosus*) had a positive effect on alcid breeding performance and populations (Chapdelaine and Brousseau 1991, 1996; Rail et al. 1996). But most population trends are left unexplained.

The fact that law enforcement efforts have not been distributed uniformly across sanctuaries probably explains why, in sanctuaries such as Île à la Brume and Baie des Loups, many seabird populations are at low levels and signs of disturbance are omnipresent. Conversely, the well-patrolled Îles Sainte-Marie Bird Sanctuary appears in good shape. Seabird conservation in North Shore bird sanctuaries face many challenges: ecotourism, disturbance, poaching, episodic fox invasion in the sanctuaries, seabird bycatch in nearby fishing nets, along with ecological factors at all scales. This stresses the need to maintain and improve law enforcement and public educational programs, and highlights the importance of research to tackle the factors responsible for the observed seabird population trends.

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Notes

Observations of Above-Surface Littoral Foraging in Two Sea Ducks, Barrow's Goldeneye, *Bucephala islandica,* and Surf Scoter, *Melanitta perspicillata,* in Coastal Southwestern British Columbia

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Lacroix, Deborah L., Kenneth G. Wright, and Daniel Kent. 2004. Observation of above-surface littoral foraging in two sea ducks, Barrow's Goldeneye, *Bucephala islandica*, and Surf Scoter, *Melanitta perspicillata*, in coastal southwestern British Columbia. Canadian Field-Naturalist 118(2): 264-265.

Barrow's Goldeneyes (*Bucephala islandica*) and Surf Scoters (*Melanitta perspicillata*) were observed on four separate occasions, by three different observers, foraging on Bay Mussels (*Mytilus trossulus*) above the water surface. This unique foraging behaviour could be attributed to diurnal spring tides and reduced lower intertidal mussel abundance.

Key Words: Barrow's Goldeneye, *Bucephala islandica*, Surf Scoter, *Melanitta perspicillata*, foraging behaviour, sea ducks, Bay Mussels, *Mytilus trossulus,* British Columbia.

The sea ducks, Barrow's Goldeneye (*Bucephala islandica*) and Surf Scoter (*Melanitta perspicillata*), winter in abundance along the coast of British Columbia where they forage diurnally on marine invertebrates in bays, harbours, beaches, and inlets (Bellrose 1980; Vermeer 1981, 1982; Vermeer and Bourne 1984; Campbell et al. 1990; Savard et al. 1998; Eadie et al. 2000). In rocky habitats, both sea ducks forage predominantly on Bay Mussels (*Mytilus trossulus*) (formerly classified as *M. edulis*; McDonald and Koehn 1988, McDonald et al. 1991) (Vermeer and Levings 1977; Hirsch 1980; Vermeer 1981, 1982; Vermeer and Bourne 1984; Lacroix 2001). Both sea ducks dive to locate and retrieve mussels. Mussels are pried from the substrate and swallowed whole (Savard et al. 1998; Eadie et al. 2000).

Three observers, on four separate occasions, observed Surf Scoters and/or Barrow's Goldeneyes foraging on Bay Mussels above the water surface in coastal southwestern British Columbia. The first observation, on 22 February 1999, involved juvenile male and female Surf Scoters and Barrow's Goldeneyes eating exposed mussels at a breakwater on Popham Island. The event was photo-documented by D. Kent. On the second occasion, on 7 March 1999, 1 juvenile male and 7 females, mostly juveniles, Barrow's Goldeneyes and 3 Surf Scoters, (1 female and 2 immature males), removed mussels from a rocky point at Cape Roger Curtis, while they sat on a reef, 1.5 m above the water line. Later that day a flock of approximately 12 Barrow's Goldeneyes, mostly juveniles, was seen feeding on mussels while hauled out on a reef on Hermit Island. This above-surface foraging tactic was also noticed later in March when three juvenile Surf Scoters, and six Barrow's Goldeneyes, mostly juveniles, fed on exposed mussels on large boulders. All the observations coincided with low diurnal tides. The tide height ranged between 1.74 to 2.16 m, above Chart Datum (a.c.d.). We are unaware of any previously published or unpublished accounts of this foraging behaviour. Our multiple observations suggest that the behaviour occurs frequently but has gone unreported.

All of these observations were made during late February and March in Howe Sound and Burrard Inlet, British Columbia, located in the same geographic vicinity (49°19.32'N, 123°09.92'W – 49°21.60'N, 123°29.15'W). These observations share several similar characteristics including: (1) all ducks were feeding on Bay Mussels; (2) the observations were made during low diurnal tides; (3) only small groups, often consisting of mixed-species flocks, were exhibiting this foraging behaviour, and (4) these foraging groups consisted mostly of juveniles.

Discussion

Bay Mussels are a dominant species in protected coastal rocky intertidal areas (Seed and Suchanek 1992; Ricketts et al. 1995). In our observation area, the vertical distribution of the Bay Mussel ranges from 1.5 to 3.7 m, a.c.d. (Quayle 1978). Although Bay Mussels are intertidal, mussel beds are rarely completely exposed during daylight hours in winter as the lowest low tides of the semidiurnal tidal regime occur at night (Thomson 1981). As winter advances into spring, the lowest low tides are diurnal; therefore expose mussel beds during daylight hours (Figure 1). Exposed mussels

FIGURE 1

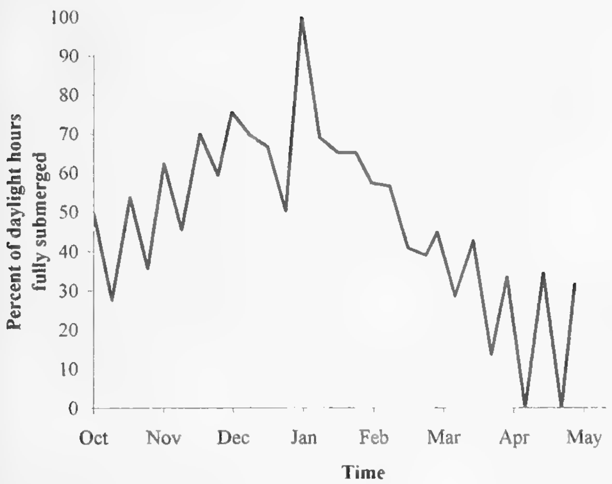

FIGURE 1. The percent of daylight hours that Bay Mussel beds are completely submerged in coastal British Columbia. Mussel submergence time was estimated by calculating the number of hours the tide was above 3.7 m, a.c.d, using Canadian tide charts (1999), during daylight hours, between sunrise and sunset.

may be more vulnerable to diving ducks such as Surf Scoter and Barrow's Goldeneye as the ducks do not need to expend energy diving to reach the mussels. However, Smeathers and Vincent (1979) found that mussels exposed to air have twice the tensile strength of those submerged. If the exposed mussels have undergone some degree of desiccation, they may require more energy to remove than submerged ones, and may therefore, not be as profitable as first postulated. Alternatively, juvenile and sub-adult Surf Scoters and Barrow's Goldeneyes may be forced to feed on exposed mussels owing to the reduced mussel abundance and distribution from over-winter predation. The lower portion of the distribution of Bay Mussels is determined by biological factors, primarily predation from the Ochre Sea Star (*Pisaster ochraceus*) (Seed and Suchanek 1992; Quayle 1978) and sea ducks (Lacroix 2001). Through the winter, the combination of sea star and sea duck predation may eliminate the lower distribution of mussels, hence reducing their overall abundance. It is therefore plausible that the ducks observed were forced to forage on the less profitable prey (i.e., the exposed mussels) because there are few or no submerged mussels in the lower portion of their distribution.

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New Records of Cyperaceae and Juncaceae from the Yukon Territory

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Harris, Stuart A., and Peter W. Ball. 2004. New records of Cyperaceae and Juncaceae from the Yukon Territory. Canadian Field-Naturalist 118(2): 269-270.

Two new species of Cyperaceae are reported, viz., *Carex hoodii,* and *Eleocharis elliptica.* Also, range extensions for eight species of *Carex, Eriophorum,* and *Juncus* are listed.

Key Words: Vascular plants, Yukon Territory, new records, range extensions.

In the last ten years, considerable advances have taken place in the knowledge of the vascular flora of the Yukon Territory (Cody, 1996, 2000; Cody et al., 1998, 2000, 2001, 2002, 2003). In spite of this, the flora is still incompletely known, as indicated by the frequent and substantial additions.

In 1980, the first author commenced detailed field studies of the distribution of permafrost in the south and central Yukon Territory, together with the nature and dynamics of the associated landforms (Harris 1998, 2004; see also Wall et al. 1987). As part of the work, plants were collected and have been systematically identified. For the more difficult groups, the material was sent to specialists who have helped in the identification. P.W.B. carried out the task of identifying the Cyperaceae and some of the Juncaceae. The result is a substantial collection of sheets that are in the collection of the first author (UAC #60 000 – 74 000). Comparison of these with the published lists of species and their distributions indicates that there are at least two species not previously described for the Yukon Territory, as well as some range extensions and name changes of varying importance. This paper will describe these changes. The nomenclature used follows that in the recent Flora of North America, volume 23 (Flora of North America Editorial Committee 2002).

Species New to the Yukon

CYPERACEAE

Carex Hoodii Boott – YUKON. Hart River road at 1180 m elevation, east of the Dempster Highway at km 78, about 138°14'W., 64°30'N. (UAC 66735).

It occurs on the wet shrub tundra between the clumps of *Betula glandulosa* and *Salix* spp., and is unlike any of the other *Carex* species. This species should be added to the list of rare plants in the Yukon (Douglas et al. 1981).

Eleocharis elliptica Kunth. – YUKON. Klondike River bridge, Dempster Highway at 138°44'W., 63°59'N. (UAC 70230).

This North American species is widespread in Alberta (Moss 1983, page 158), and should be looked for elsewhere in the southern Yukon Territory. It is characterised by yellow, orange or brown achenes with 12-20 vertical ridges. It should be added to the list of rare plants of the Yukon Territory (Douglas et al. 1981).

Range Extensions in the Yukon

CYPERACEAE

Carex foenea Willdenow – YUKON. Tagish Campground, 134°15'W., 60°19'N. (UAC 70310), and Lucky Lake, east of Watson Lake, 134°30'W., 60°01'N. (UAC 61656).

It is probably present at scattered localities across the southern Yukon Territory in wet places in Lodgepole Pine forests. It has previously been found in three localities (Cody, 1994, page 149; Cody et al. 1998, page 301) including Watson Lake.

Carex glareosa Wahlenburg – YUKON. Minto Landing in grassy glades at 136°53'W., 62°03'N. (UAC 70268).

Douglas et al. (1981), and Cody (1994, page 440; 1996; Cody et al. 1998, page 301) have previously reported it from north of the 69th parallel, but this represents a large extension of its range southwards by some 7° of latitude.

Carex lapponica O. F. Lang – YUKON. Sheldon Lake, 131°13'W., 61°38'N. (UAC 70271).

Cody et al. (1988, page 301) had earlier collected it in the extreme southeast of the Territory.

Carex magellanica Lamark ssp. *irrigua* (Wahlenburg) Hiitonen – YUKON. Watson Lake at 128°41'W., 60°03'N. (UAC 73050).

It was previously collected further west and north (Cody, 1996, page 157) and further east (Cody et al. 1998, page 302).

Carex marina Dewey – YUKON. Minto Landing, at 136°53'W., 62°03'N. (UAC 66965), as a rare component of the grassy open areas in the boreal forest along the river bank, close to the steep, grassy, south-facing slopes of the valley walls.

This is presumably an extension of its limited range in adjacent south-central Alaska in the rain shadow of the Wrangel Mountains (Hultén, 1968, page 239). Cody (1996, page 157) only reported it from Herschel Island, the Lower Blow River delta (Cody et al. 1998, page 303), and the Malcolm River delta.

Carex pachystachya Chamisso ex Steudel – YUKON. Macmillan Pass between 1097 m and 1250 m at 130°30'W., 63°21'N. and 130°06'W., 63°23'N. (UAC 61619, 61620), Tombstone Mountain Campground, km 75, Dempster Highway, about 138°14'W., 64°30'N. (UAC 61615), and Dragon Lake, North Canol Road, 131°20'W., 62°33'N. (UAC 70287).

These sites represent a large range extension from the south Yukon (Cody 1996, page 162) to the northern limit of the Boreal Forest. Harris (1998, page 269) previously listed it as being present at km 161.7, Robert Campbell Highway. It's rarity needs to be verified.

JUNCACEAE

Juncus stygius Linnaeus ssp. *americanus* (Buch.) Hultn – YUKON. Thermokarst Mounds, South Fork, Blackstone River, Dempster Highway at 138°22'W., 64°48'N., July 1987 (UAC 70257).

Cody (1996, page 190) previously reported it from the Keno Hill area, while Cody et al. (1998, page 305) found it at Coal River in the southeast Yukon.

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"Ashkui" Vernal Ice-cover Phenomena and Their Ecological Role in Southern Labrador

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This is the first documented incident of River Otter *(Lutra canadensis)* feeding on Common Goldeneye *(Bucephala clangula)* in a little studied region, southern Labrador. Our observations were made during spring staging when waterfowl aggregate at open water sites in frozen lakes and rivers, locally known as *ashkui.* We suggest that otters and raptors opportunistically forage on staging waterfowl at *ashkui.*

Key Words: River Otter, *Lutra canadensis,* Common Goldeneye, *Bucephala, clangula,* Bald Eagle, *Haliaeetus leucocephalus,* predator-prey interactions, staging waterfowl, ashkui, Labrador.

Ashkui (singular and plural form) is the Innu name given to sites of open water in river and lake systems within the frozen spring landscape of Labrador (Fletcher and Breeze 2000*). Migratory waterfowl, including Common Goldeneye *(Bucephala clangula),* use *ashkui* as staging areas enroute to their breeding grounds. These birds arrive in groups of tens to hundreds to rest and rebuild energy reserves by feeding on invertebrates, fish, seeds and other plant material at *ashkui* (Newbury 2002*). Beaver *(Castor canadensis),* River Otter *(Lutra canadensis)* and Muskrat *(Ondatra zibethicus),* have been observed at these sites. Osprey *(Pandion haliaetus)* and Bald Eagle *(Haliaeetus leucocephalus)* are known to fish at *ashkui* (Fletcher and Breeze 2000*). The temporal existence, number and distribution of *ashkui* sites are influenced by a high

degree of inter-annual variability in the onset of spring thaw. As the winter snows disintegrate and waterfowl await availability of breeding habitat, they may be susceptible to predation. In 2002, the opening of *ashkui* occurred two weeks later than in previous years (unpublished data, Environment Canada, St. John's, Newfoundland).

Our observations were made during a study examining the effects of military low level flying on the behaviour of staging waterfowl at Lac Fourmont in southern Labrador (52°00'N, 60°15'W; Newbury 2004*). While conducting waterfowl behavioural observations, we witnessed a River Otter feeding on a male Common Goldeneye. We also observed a Bald Eagle attack another goldeneye resting on the ice.

Study Area

Lac Fourmont is situated within the Boreal Forest Region of eastern Canada and is influenced by continental climatic regimes (Lopoukhine et al. 1977*). This region is covered with ice and snow until daily spring thaw temperatures rise to 5.1°C in May (30 year average for Goose Bay, Labrador; Environment Canada Meteorological Service, St. John's, Newfoundland). Daytime average temperatures were 4.1°C in May 2002 and ranged from 4.0 to 9.0°C for May during the years 1993 to 2002. River width at the observation location was approximately 1 km, and the *ashkui* site was 20 m in breadth. Ice breadth from *ashkui* to shoreline was approximately 50 m. Forest stands were composed of mainly Black Spruce *(Picea mariana)* and Balsam Fir *(Abies balsamea)* interspersed with approximately 10 % Paper Birch *(Betula papyrifera),* Balsam Poplar *(Populus balsamifera),* and Trembling Aspen *(Populus tremuloides).* Lake-edge shrubs consisted of willows *(Salix* spp.) and alders *(Alnus rugosa* and *A. crispa).* River and bank substrate was composed of coarse-grained sand and pebbles with exposed boulders and bedrock of gneiss and mafic intrusions. River basin and landscape were low gradient with shallow sloping banks, wide flood plain and low relief hills.

We conducted daily observations on waterfowl behaviour from blinds using a Swarovski 60× spotting scope from 9:00 to 12:00 and 13:00 to 16:00 between 26 April and 27 May 2002. Also, we conducted thirteen random 1.5 h watches during dawn and dusk.

Observations

Fourteen species of waterfowl occupied the Lac Fourmont *ashkui.* Daily waterfowl numbers at the *ashkui* ranged from 34 to 376 during this study. A single River Otter was noted at the *ashkui* during at least five observation days. The number of sightings of mature and immature Bald Eagles, Osprey and Rough-legged Hawk *(Buteo lagopus)* totaled 7, 2, 1 and 1, respectively, over 8 non-consecutive study days.

On 6 May 2002 at 11:35, we observed a River Otter grasping a male Common Goldeneye on the ice, approximately 70 m from our observation blind on the south side of the *ashkui.* Although the capture was not observed, the goldeneye was alive and struggling when the otter was initially observed. The otter sat on its rear haunches with the goldeneye braced in its forepaws and consumed the head of the duck first before eating the breast muscles and abdominal viscera. After approximately 10 minutes of feeding, the otter slipped into the water and swam downstream without the carcass remains. We did not observe the fate of the duck carcass, as it was no longer visible on the ice when the otter left the feeding site. The bird flock, during this observation period, comprised mainly 65 Common Goldeneyes, 27 Black Ducks, 113 Canada Geese *(Branta canadensis).*

On 18 May 2002 at 16:03, we observed a Bald Eagle circle the *ashkui* and plunge downward toward a small group of Common Goldeneyes resting and sleeping on the ice, approximately 150 m from our position. Upon impact, the eagle initially captured a goldeneye. The eagle then struggled with the goldeneye while standing on the ice edge but was unable to maintain its grasp. The goldeneye fell from the ice to the water then became inter-mixed with the flock. This interaction lasted approximately one minute and, we were unable to identify the attacked goldeneye after its escape. The eagle then flew to the other side of the *ashkui* and rested on the ice. The bird flock, during this observation, comprised mainly 7 Common Goldeneyes, 29 Black Ducks *(Anas rubripes),* 67 Canada Geese *(Branta canadensis),* 11 Greater Scaup *(Aythya marila)* and 20 Ring-necked Ducks *(Aythya collards).*

Discussion

Fish are often the main prey of River Otter and raptorial predators (Chubbs and Trimper 1998; Larivière and Walton 1998; Fletcher and Breeze 2000*; Heath et al. 2001; Jedrzejewska et al. 2001). Studies in the Great Lakes and North American boreal ecosystems have shown that the diet of River Otter comprises mostly fish (Larivière and Walton 1998). However, otters have been known to feed opportunistically on small mammals, molluscs, reptiles, birds and fruits (Larivière and Walton 1998). In west-central Idaho, otters supplemented their fish diet with invertebrates and reptiles (Melquist and Hornocker 1983). In Great Britain and Ireland, otters consume primarily fish, and lesser amounts of small mammals, medium-sized mammals, birds, herpetofauna, earthworms, other invertebrates and carrion of large mammals (McDonald 2002). Jedrzejewska et al. (2001) showed that otters specialize on prey taken from water. It is plausible that an otter fishing for fish under water may opportunistically capture diving goldeneyes. Although River Otters were known to occasionally feed on birds (Larivière and Walton 1998), we believe that this was the first documented case of an otter feeding on a Common Goldeneye.

Instances of Bald Eagles preying on duck species are not rare (Jackman et al. 1999; Heath et al. 2001). Although fish dominate their diet, Bald Eagles have been reported to modify foraging behaviour and may forage opportunistically on staging waterfowl in situations where return on such effort makes them economical (Brown et al. 1998; Jackman et al. 1999).

The temporal existence, number and distribution of *ashkui,* in southern Labrador during spring, may influence the spatial and temporal distribution of piscivorous predators and migratory waterfowl by limiting the availability of open-water feeding and resting areas. Migratory waterfowl arriving from southern destinations must accumulate in greater concentrations when *ashkui* openings are limited. Though the behaviour and distribution of River Otter were not documented for Labrador, Larivière and Walton (1998) stated that otters made heavy use of *ashkui* in winter and "almost exclusively" used open water for locomotion and foraging (Madsen and Prang 2001; Ruiz-Olmo et al. 2001). Piscivorous raptors returning to breeding areas must travel to and congregate at available *ashkui* to fish. It was likely that spatial and temporal distribution of *ashkui* also affected predator-prey interactions.

Our observations are examples of opportunistic foraging events on waterfowl by predators that appear to use *ashkui* regardless of the presence of waterfowl. Further investigations in Labrador are needed to understand better the ecological importance of the temporal and spatial distribution of *ashkui* to mammalian and raptorial predators.

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Sea Otter, *Enhydra lutris*, Sightings off Haida Gwaii / Queen Charlotte Islands, British Columbia, 1972-2002

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Raum-Suryan, Kimberly, Kenneth Pitcher, and Richard Lamy. 2004. Sea Otter, *Enhydra lutris*, sightings off Haida Gwaii/Queen Charlotte Islands, British Columbia, 1972-2002. Canadian Field-Naturalist 118(2): 270-272.

On 27 June 2001 we observed and photographed a Sea Otter (*Enhydra lutris*) adjacent to a Steller Sea Lion (*Eumetopias jubatus*) haulout near Sgang Gwaay (Anthony Island), Haida Gwaii / Queen Charlotte Islands. This is one of only eight documented sightings of Sea Otters in these waters during the past 30 years. These sightings may represent the beginning of the expansion of Sea Otters to their former range off Haida Gwaii.

Key Words: Sea Otter, *Enhydra lutris*, Haida Gwaii, Queen Charlotte Islands, British Columbia.

The Sea Otter (*Enhydra lutris*) once ranged in nearshore waters along the North Pacific Rim from Japan to Baja California. The worldwide population of Sea Otters in the early 1700s was estimated to be between 150 000 (Kenyon 1969) and 300 000 animals (Johnson 1982). Middens (human food waste mounds) indicate that aboriginal people, including the Haida, hunted Sea Otters (Simenstad et al. 1978; Acheson 1998; Sloan 2004). Although this harvest may have caused local reductions of Sea Otter populations near village sites (Simenstad et al. 1978), the species was abundant throughout its range prior to commercial exploitation. Following the advent of commercial hunting in 1741, the worldwide population of Sea Otters declined to less than 2000 animals by 1911, limited to remnant groups throughout the range (Kenyon 1969). Many of these remnant groups (including one group located off the Haida Gwaii / Queen Charlotte Islands, British Columbia, Canada) were extirpated, likely due to their small size (Watson et al. 1997). The last Sea Otter recorded from Haida Gwaii was before 1920 (Kenyon 1969) and the last recorded in British Columbia, near Vancouver Island (prior to reintroduction), was in 1929 (Cowan and Guiguet 1960; Kenyon 1969).

In 1911 an International Treaty provided protection of Sea Otters from additional exploitation. Furthermore, to aid in the recovery of Sea Otters, various translocation projects were conducted from the 1950s to early 1970s in the Pacific coastal United States and Canada (Kenyon and Spencer 1960; Kenyon 1969; Burris and McKnight 1973; Bigg and MacAskie 1978; Jameson et al. 1982; Jameson et al. 1986; Riedman and Estes 1990). Since reintroduction, the Sea Otter population in British Columbia has increased 18.6% per year from 70 animals in 1977 to an estimated 2 500 animals in 1998 (Watson 2000). Although Sea Otters continue to expand their range along Vancouver Island and the central coast of British Columbia (Watson 2000; Figure 1), sightings off Haida Gwaii / Queen Charlotte Islands remain rare.

On 27 June 2001 we observed and photographed a Sea Otter of unknown sex adjacent to a Steller Sea Lion haulout (52°04.966' N, 131°13.811' W) just south of Sgang Gwaay (Anthony Island), Haida Gwaii / Queen Charlotte Islands (Figure 1). The Sea Otter was swimming on its back eating a sea urchin (*Strongylocentrotus* sp.). We observed the otter for approximately 30 minutes as it swam and dove. This observation is one of only eight documented sightings (Edie 1973; Taylor and Gough 1977; Heise et al. 2003) of Sea Otters in waters surrounding Haida Gwaii / Queen Charlotte Islands during the past 30 years (Figure 1).

This sighting raises some interesting questions regarding the origin of this individual and whether or not Sea Otters are expanding their range to include the Haida Gwaii / Queen Charlotte Islands once again. Kenyon (1969) suggested that the most significant factor limiting the spread of Sea Otter populations is a tendency of individual Sea Otters to occupy a limited home range. Although Sea Otters are not known to migrate, as populations increase, males generally are the first to explore new areas and their presence sometimes indicates imminent range reoccupation (Loughlin 1980; Garshelis et al. 1984; Pitcher 1989). Garshelis and Garshelis (1984) recorded long-distance movements of > 100 km for five adult territorial males. They postulated that the Sea Otters might have left an area of limited food resources to travel to an area where food was more abundant. When Sea Otters were extirpated, many of their primary benthic invertebrate prey became larger and more abundant (Estes and Palmisano 1974; Garshelis et al. 1986). When Sea Otters recolonize they initially encounter more abundant and larger prey resources than may be expected to persist, leading to densities of Sea Otters in recovering populations greater than those that can be sustainable over

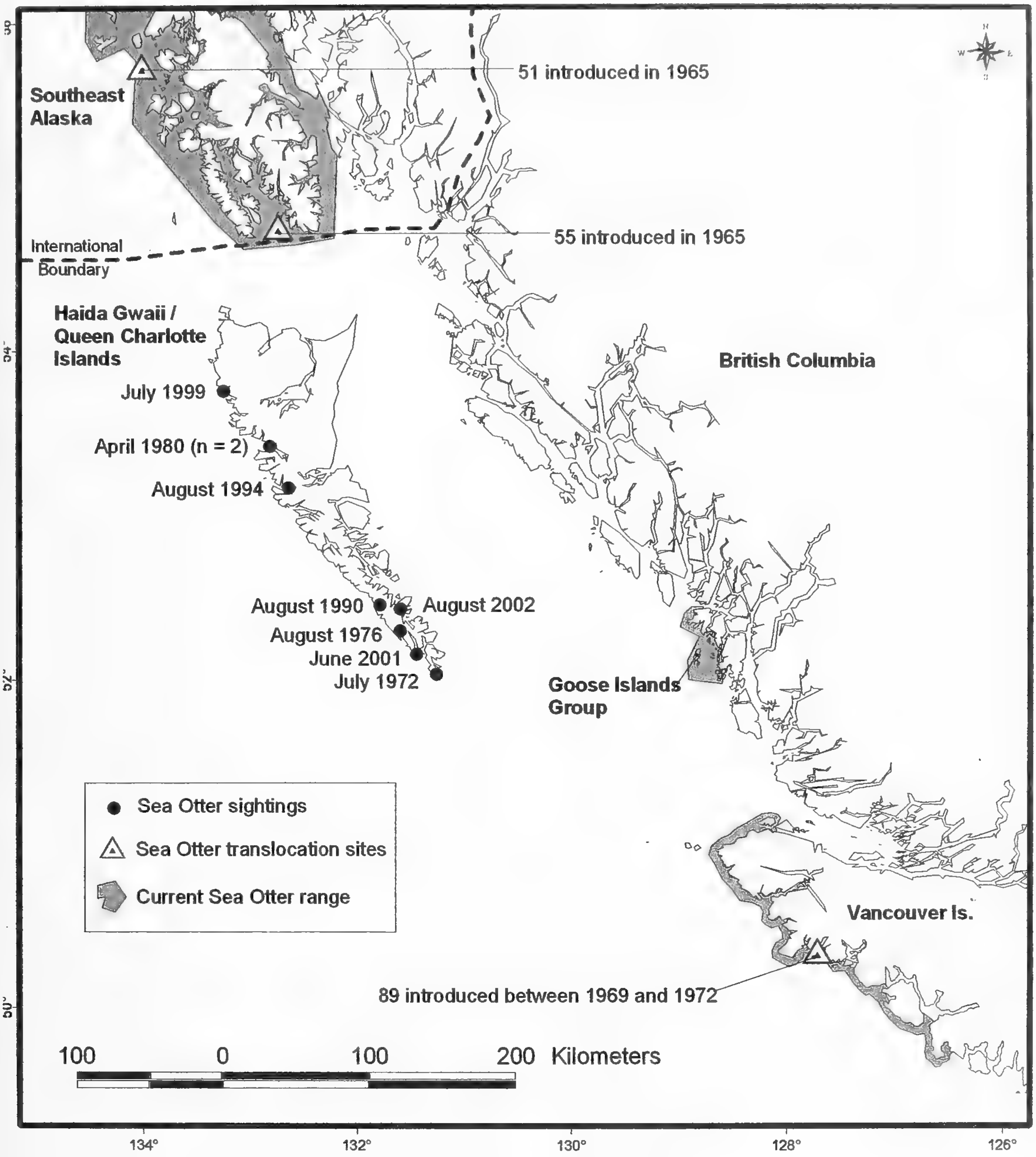

FIGURE 1. Sightings of Sea Otters around Haida Gwaii / Queen Charlotte Islands, locations of Sea Otter translocations nearest Haida Gwaii, and current Sea Otter distribution in Southeast Alaska and British Columbia (map adapted from Parks Canada Report 038, Living marine legacy of Gwaii Haanas. IV: Marine mammal baseline to 2003 and marine mammal-related management issues throughout the Haida Gwaii region by Heise et al. 2003).

time (Bodkin et al. 2000). As prey is consumed, Sea Otter densities should decline and fluctuate at an equilibrium density (Estes 1990) through decreased reproduction, increased mortality, or through emigration (Bodkin et al. 2000).

Sea Otter population increases in the Aleutian Islands were achieved largely by range expansion over deep, wide ocean passes (Estes 1990). Unless the Sea Otter we observed is a member of a previously undetected group off Haida Gwaii / Queen Charlotte Islands, this individual would have had to travel at least 175 km across an open expanse of water from the nearest known group of otters along the British Columbia coast (Figure 1). If this individual traveled from southeast

Alaska or northern Vancouver Island, the distance would be even greater. If Sea Otter populations have reached or exceeded carrying capacity in certain regions of British Columbia or southeast Alaska (Watson et al. 1997; Watson 2000), this may be the beginning of the expansion of Sea Otters to their former range off Haida Gwaii / Queen Charlotte Islands. This range expansion may be particularly important given the precipitous population decline of Western Alaska Sea Otters during the past 15 years (Doroff et al. 2003) and the proposal to list the population as threatened under the United States Endangered Species Act (Federal Register: 11 February 2004; Volume 69, Number 28).

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First Record of a Barred Owl, *Strix varia*, in Labrador

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A Barred Owl (*Strix varia*) was heard calling in central Labrador, Canada in 2001, and a dead owl was found in the same area in 2004. These are the first confirmed records for the Province of Newfoundland and Labrador.

Key Words: *Strix varia*, Barred Owl, range, vagrant, Newfoundland and Labrador.

Barred Owls (*Strix varia*) are common in southern Canadian forests from British Columbia through Nova Scotia (AOU 1998), occurring in mixed evergreen and mature deciduous woodlands, but also into the boreal forest in the northern portion of its range (Erskine 1977; Godfrey 1986; Mazur et al. 1998). There are no confirmed records of Barred Owls for the Province of Newfoundland and Labrador (Todd 1963; ACCDC 2004*). We document two occurrences of a Barred Owl near Happy Valley – Goose Bay, Labrador, three years apart.

On the evening of 24 August 2001, at 22:00 hrs, a lone Barred Owl was heard calling in the forest north of Happy-Valley Goose Bay, Labrador, along the banks of the Goose River (53° 24'N, 60° 26'W) by one of the authors (IS) (Figure 1). The owl called continuously for several minutes from the same location, approximately 250 m away. The song was made up of the characteristic pattern of 8 hoots, separated into two parts by a pause after 4 hoots, and ending with a characteristic descending pitch on the last hoot ('*hoohoo hoohoo, hoohoo hoohooahhw*'). The calls of this owl may be unfamiliar to residents of Labrador, but Barred Owl calls are very distinctive, and were immediately recognizable to one of the authors (IS). The only other owl species in the area with which the calls could possibly be confused is the Great Horned Owl (*Bubo virginianus*), whose call is of a deeper tone, and consists of five or six hoots, beginning with one emphatic hoot, followed by several shorter and quieter calls, and ending with two long hoots on the same pitch ('*Hooo! hoohoohoo Hoooo, Hoooo'*). The calls of the two owls differ in tone, pattern and rhythm, and are not difficult to tell apart by experienced listeners.

Using a vocal imitation of the call, the author attempted to elicit a callback. The owl responded by leaving its perch, approaching her, and selecting a new perch within 50 m of her location. It made no other movements, and she was able to elicit vocal responses to her calls for nearly an hour. During this period, the owl occasionally varied its call either by repeating only the last section '*hoohooahhw*', or by shortening the first section to a rising series of 3 notes followed immediately by the distinctive descending cackle ('*hoohoohoo hoohooahhw*'). Unfortunately, due to darkness and heavy forest cover, the owl was not sighted. At the time of observation, the air temperature was 10°C, winds were calm, and the skies were clear. Tourists camped at the site reported hearing the same calls during the previous evening.

On the evenings of 26, 28, and 31 August, at approximately 22:00, IS returned to the area to perform a nocturnal callback survey (using a vocal imitation of the call) to check for the presence of the owl. Roads and paths in forested areas within 10 km of the original sighting were surveyed, with stops every 0.3 – 0.5 km, and several minutes spent at each station calling and listening for a response. No Barred owls were detected during these subsequent surveys.

The second observation occurred three years later, in virtually the same location (53° 27'N 60° 18'W, on 16 July 2004 (Figure 1). A dead owl was seen on the side of Route 530, at approximately 08:00 hrs. On closer inspection, the owl carcass showed no obvious sign of injury or illness, and was completely intact, with no sign of scavenging, and no fly larvae. The eyes were present and moist (not sunken, retracted, or absent as in older kills). Given the abundance of foxes (*Vulpes vulpes*), Ravens (*Corvus corax*), Gray Jays (*Perisoreus canadensis*) and other scavengers, it is the opinion of the authors that the owl had been dead for a few hours at most.

Field marks on the owl included dark eyes, vertical barring on the belly and short, horizontal bars across the chest, all characteristic of Barred Owls (Figure 2). The owl was also assessed using the criteria of Pyle (1997). The lack of down on the head and contour feathers, flight feathers that were broad and uniform in color and wear, and the presence of squared bars on the primary coverts all suggest the bird was an adult (After Hatch Year or AHY). On dissection, the owl was determined to be a female by the presence of an ovary. No brood patch was present.

Barred owls have been observed in Québec north of the St. Lawrence River (Gagnon and Bombardier 1996). The breeding range has been reported to extend

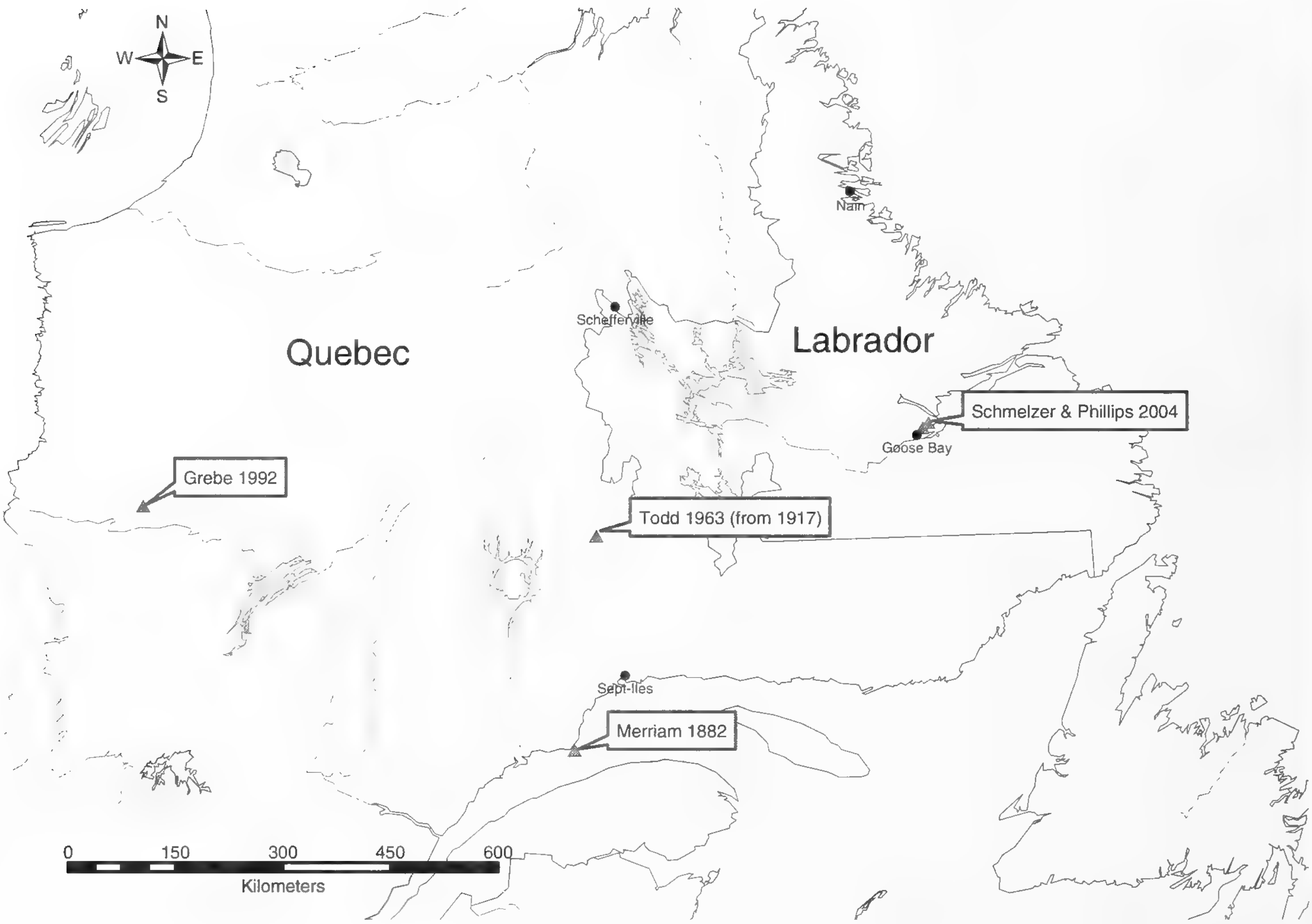

FIGURE 1. A summary of Barred Owl records in Labrador and nearby Quebec. Further description of the records is given in the text.

to 50° North in eastern Canada (David 1980; Godfrey 1986). Our review of the literature, however, revealed several sightings north of this latitude in Québec. For example, a Barred Owl was reported near Lac aux Cèdres, 52° 00'N, 67° 07'W, near the Labrador border in 1917 (Todd 1963). It has been reported more recently further west near Nemiscau, 51° 42'N, 76° 15'W, and Lake Evans, 50° 55'N, 77° 00'W, (Grebe 1992). Additionally, Comeau referred to the bird as "tolerably common" near Godbout, 49° 19'N, 67° 18'W, on the North Shore of the Gulf of St. Lawrence (in Merriam 1882), and a specimen was captured at Lac Paterson in Roberval County (50° 11'N, longitude not specified) in 1954 (Godfrey 1957). Nonetheless, the occurrence of the owl in central Labrador is 500 km distant from the nearest previous report, and 700 km outside regions where the species is noted regularly.

During the past several decades, the geographic range of the Barred Owl has expanded in western North America, and most recent discussion has focused on its movements into the Pacific Northwest (Levy 1999; Boxall and Stepney 1982; Wright and Hayward 1998). However, on the basis of sightings in Quebec north of the St. Lawrence River, Harper (1958) proposed that the range of the Barred Owl was also extending northward in eastern North America. Although the Gulf of St. Lawrence and the Strait of Belle Isle present significant barriers to occurrence on the island of Newfoundland, the forests of Quebec and Labrador are continuous and present no obstacles to movement. The environs of Happy Valley – Goose Bay, including the Churchill River valley and coastal plain surrounding Lake Melville, belong to the 'High Boreal Forest' ecoregions, (Government of Newfoundland and Labrador 2004*) and consist of mature, dense mixed deciduous/coniferous forest on sandy soil. Predominant tree species are Trembling Aspen (*Populus tremuloides*) and White Birch (*Betula papyrifera*), with coniferous species such as Balsam Fir (*Abies balsamea*), and White and Black spruce (*Picea glauca, P. mariana*) occurring secondarily. Suitable breeding habitat for Barred Owls is often associated with the presence of snags used as nest cavities (Haney 1997), but also nests of other raptors or corvids (Elderkin 1987). This region features the most favorable climate in all of Labrador, including a growing season of 120-140 days. Conversely, the upland plateaus of central and western Labrador are

FIGURE 2: Adult female Barred Owl collected near Happy Valley – Goose Bay in July 2004, which showed characteristic gray-brown coloration, yellow bill, vertical barring on the belly and horizontal barring on the chest. Flight feathers (right wing shown) are broad and uniform in colour and wear, suggesting an adult bird that has not yet molted.

characterized by a subarctic forest and climate, and border the former ecoregion to the north and west. The elevation, vegetative communities, and severe climate may pose a barrier to an eastward expansion from northern Québec. To the south and east however, broad river valleys and mixedwood boreal forests predominate.

In the absence of evidence of breeding, it is unknown whether this record represents a possible range expansion by the Barred Owl, or simply documents the occurrence of a vagrant bird in potentially suitable habitat on two separate occasions. The fact that in one instance the owl was an adult female, and that she was found within the breeding season, does not preclude range expansion as a possible explanation. The absence of geographical barriers to movement from northeastern Quebec, particularly from the north shore of the St. Lawrence, into south-central Labrador supports this notion. The establishment of owl surveys in Labrador should help to clarify such questions, and others, in the future.

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Forked Three-awned Grass, *Aristida basiramea* Engelm. ex Vasey: A New Addition to the Flora of Quebec

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Brisson, Jacques. 2004. Forked Three-awned Grass, *Aristida basiramea* Engelm. ex Vasey: a new addition to the flora of Quebec. Canadian Field-Naturalist 118(2): 276-277.

A population of Forked Three-awned Grass (*Aristida basiramea* Engelm. ex Vasey; Poaceae) was found for the first time in Quebec, on a sand barren of the Cazaville region (Haut-Saint-Laurent). The only other region where this species is known in Canada is on the southern side of Georgian Bay in Ontario.

Key Words: *Aristida basiramea*, Forked Three-awned Grass, Poaceae, rare plants, Quebec

Une population d'*Aristida basiramea* Engelm. ex Vasey (Poaceae) fut trouvée pour la première fois au Québec, dans une lande sableuse de la région de Cazaville (Haut-Saint-Laurent). Le seul autre endroit où l'espèce est présente au Canada est sur le côté sud de la Baie Georgienne en Ontario.

Mots-clés : *Aristida basiramea*, Poaceae, plantes rares, Québec

In September 2001, during an ecological survey near Cazaville, in the Haut-Saint-Laurent region of southern Quebec, a population of Forked Three-awned Grass (*Aristida basiramea* Engelm. ex Vasey) was found in a dry, sandy grass-field. Other populations were later located in similar habitats nearby. This is the first time the species has been reported for Quebec. In Canada, *A. basiramea* is known from four extant naturally-occurring sites located in southern Ontario, three of which are in Simcoe County, and one in Muskoka County (Allen 2001). The extent of occurrence in Ontario only totals 16 hectares. There is also one adventive station in northwestern Ontario, at Rainy River (Allen 2001). A few other reports exist, such as one in Norfolk County in Ontario, and a few more in Manitoba. However, the locality of the Norfolk specimen may be the result of a labelling error (Reznicek 1984), while the reports from Manitoba are considered questionable due to the absence of existing specimens (Scoggan 1957; Allen 2001). Thus, the Cazaville area becomes the second area in Canada where the presence of the species is confirmed. The species is listed as rare in Ontario (Reznicek 1984) and is considered threatened in Canada (COSEWIC 2003). On the basis of the newly discovered population, *A. basiramea* should be added to the list of rare vascular plants likely to be designated threatened or vulnerable (Labrecque and Lavoie 2002).

The genus *Aristida* is represented by 250 to 300 species, 29 of which are native to North America north of Mexico (Flora of North America Editorial Committee 2003). *A. basiramea* is an annual plant from 30 to 60 cm high characterized by glumes of unequal length and 1-flowered spikelets terminated by three long awns, one in the middle with a twisted base and two shorter straight awns on each side. It is abundant on dry sterile or sandy soil in the midwestern states. At the northeastern periphery of its range in the United States, it forms disjunct populations on dry lands and along sandy roadsides, some populations of which appear to be adventive. The closest reports of *A. basiramea* south of the border with Québec were from Plattsburg, Clinton Co., New York (S. J. Smith, 25 July 1965, NYS); Columbia, northern Coos Co., New Hampshire (A. S. Pease, 17 September 1955, NEBC); and Avon, Franklin Co., Maine (A. Haines, 26 October 1990, MAINE). The species is recognized as rare in Maine, Iowa and Colorado (Allen 2001).

The Cazaville area (45°03' N, 74°22' W) is located in the Mixed Plain Ecozone of the St-Lawrence Lowland Ecoregion (Ecological Stratification Working Group 1995). The area is characterized by a vast sandy plain of littoral origin dating from the last post-glacial period. White Pine (*Pinus strobus*) forests were abundant before European settlement (Brisson and Bouchard 2003), but today, the area is occupied by sandy, grassy fields, sand barrens and secondary forests of Red Maple (*Acer rubrum*), Trembling Aspen (*Populus tremuloides*) and Gray Birch (*Betula populifolia*). *Aristida basiramea* was found on open, sandy grass-field with *Poa compressa*, *Danthonia spicata*, and various types of lichens. The sandy plain of Cazaville is host to other rare plant species. The northernmost colony of *Monarda punctata*, a species rare for Quebec and Canada, was recently found nearby (Boudreault and Brisson 1994). As well, *Hedeoma hispida*, considered rare for Quebec (Labrecque and Lavoie 2002), is also found on the sandy plain.

Specimens of *A. basiramea* were deposited at the Marie-Victorin Herbarium (MT: Brisson Number JB01-25).

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Evidence for the Use of Vocalization to Coordinate the Killing of a White-Tailed Deer, *Odocoileus virginianus,* by Coyotes, *Canis latrans*

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Muntz, Erich M., and Brent R. Patterson. 2004. Evidence for the use of vocalization to coordinate the killing of a White-Tailed deer, *Odocoileus virginianus,* by Coyotes, *Canis latrans.* Canadian Field-Naturalist 118(2): 278-280.

Among the social canids, howling is largely accepted as playing a role in territory maintenance. However, its role in communication within packs, such as announcing departures from den and rendezvous sites and coordinating reunions or movements, remains largely speculative. We report an observation where a radio-collared adult male Coyote *(Canis latrans)* and his mate seemed to summon two other Coyotes (presumed to be their offspring) from ~700 m away to join in the successful pursuit of an adult male White-tailed Deer *(Odocoileus virginianus).* Our observation suggests that Coyotes can use vocalization as an effective means of coordinating social activities such as the hunting of large prey.

Key Words: Eastern Coyote, *Canis latrans,* predation, vocalization, social organization, Nova Scotia.

Auditory communication serves an important role in the social ecology of the Canidae (Harrington and Mech 1978, 1979; Theberge and Falls 1967; Gese and Ruff 1998). Howling is a means of long-distance communication that apparently can be heard at distances of > 6 km (McCarley 1975; Harrington and Mech 1979). Among Coyotes *(Canis latrans)* and Wolves *(Canis lupus),* howling is largely accepted as playing a role in territory maintenance (Joslin 1967, Harrington and Mech 1978, 1979; Gese et al. 1988). Intrapack communicatory roles, such as announcing departures from den and rendezvous sites, and coordinating reunions or movements remain largely speculative (Theberge and Falls 1967; Mech 1970; Harrington and Mech 1978). Bender et al. (1996) suggested that howling among Coyotes might serve to reunify packs to facilitate the hunting of ungulates. Herein we report a case where a breeding pair of Coyotes in pursuit of a large White-tailed Deer *(Odocoileus virginianus)* was able to entice two other Coyotes to join the pursuit from ~700 m away.

Observation

We interpreted the details of the chase while snow-tracking a radio-collared Coyote and his mate on 27 February 1994 as part of a study of the effects of the distribution and abundance of Snowshoe Hares, *Lepus americanus,* and White-tailed Deer on the life history of Coyotes in Nova Scotia (Patterson and Messier 2000, 2001; Patterson et al. 1998). The actual event probably occurred during the previous night.

Radio-collared Coyote AM3 and his mate were traveling west on a snow-covered (10-15 cm) secondary road 1 km east of Kejimkujik National Park (44°20'N, 65°15'W) when they abruptly veered due north. Lengthened strides indicated that their pace increased, and after 40 m the pair jumped three deer, of which two headed west and the other east. Both Coyotes chased the deer that ran to the east. After 280 m the two Coyotes split up, with the larger radio-collared male chasing the deer down a steep bank into a bowl-shaped depression. AM3 then swung wide to the left of the deer, apparently in an attempt to steer the deer into the path of the other Coyote that had remained on the rim of the depression. The second Coyote circled the depression and ran down the opposite side in front of the deer. We interpreted this as an effort to prevent the deer from leaving the depression.

Within 3 m of the second Coyote's resumption of the chase, both Coyotes attacked the deer and drew hair but no blood. The deer escaped and again attempted to run up the side of the depression when AM3 swung to the right and turned the deer back down into the depression, where the second Coyote was waiting and again resumed the chase. The Coyotes attacked the deer again at 383 m where a larger area of snow was trampled down than during the first attack. There was more hair strewn about, but still no blood. At this point two more Coyotes became involved in the chase. At 390 m more hair was detected as well as blood, indicating another attack. The deer broke away once more only to be attacked again at 397 m. After escaping yet again the deer made a long run across the middle of the depression. Considerable amounts of blood and hair strewn about a 20 × 30 m packed-down area at 590 m indicated a more serious struggle. The deer made one final escape and was pulled down by the front end at 630 m, with tracks indicating that the deer was drag-

ging at least two of the Coyotes, which appear to have been hanging off its sides. After dragging the Coyotes for 40 m the deer was killed at the 670 m mark.

Examination of the carcass revealed that the deer was a large 3.5 year old buck that showed no obvious debilitations and was apparently in good health (>80% femur marrow fat content and other visible body fat reserves). We believe that the deer would likely have escaped if it could have got out of the depression. The two Coyotes initially involved in the chase appeared to have trouble drawing blood from the deer until the other two Coyotes joined them. Backtracking later revealed that the two Coyotes that joined the chase in progress had been traveling in another direction when they abruptly turned and trotted 690 m in a direct line to join the chase. Forest cover was dense, precluding any possibility that these Coyotes observed the chase prior to joining in. AM3 and his mate were typically accompanied by two of their young of the year when traveling in winter 1994 (Patterson and Messier 2001). We believe that the two Coyotes that joined the chase "in progress" were probably these same juveniles that had been temporarily disassociated from their parents. We speculate that they must have heard AM3 or his mate howling or yipping and were able to determine that it would be to their benefit to join the breeding pair promptly.

Discussion

Although we can not verify that howling was used to draw the other two Coyotes to the scene of the chase, we can think of only one other means by which two Coyotes ~700 m away in forested cover may have been able to so directly and rapidly locate the scene of the chase. White-tailed Deer can snort loudly when alarmed, but snorts are generally only given when a deer perceives danger but does not feel directly threatened (Hirth and McCullough 1977; Marchinton and Hirth 1984). Furthermore, snorts are more likely to be given by maternal family groups than by bucks (Hirth and McCullough 1977). Thus it seems unlikely that snorting by the buck alerted the other two Coyotes to the chase.

Among forest-dwelling eastern Coyotes increased reproductive fitness and inclusive fitness for juveniles before dispersal seem to be the ultimate factors influencing group living (Messier and Barrette 1982; Patterson and Messier 2001). Increased efficiency at using large prey appears to be a secondary benefit (Gese et al. 1988; Messier and Barrette 1982; Patterson and Messier 2001). Coyotes in Nova Scotia were more successful at killing deer when thick snow cover impeded deer movements (Patterson and Messier 2000). There was only 10-15 cm of snow on the ground during the event described here and our observations suggest that in this particular incidence the snow cover may have been a hindrance to the Coyotes, thus benefiting the deer. It was clear that AM3 and his mate were having difficulty subduing the deer on their own. We believe that they would not likely have been able to make physical contact with the deer if it had not entered the depression. Although Patterson and Messier (2000) did not detect a consistent increase in deer killing rates for groups of 2-5 Coyotes, groups of >4 Coyotes killed proportionately more deer (Patterson 1999). We suspect that larger group sizes may be more advantageous in hunting large prey in the absence of other contributing factors such as thick snowcover or glare ice. The proximate mechanism is likely an increase in the probability of at least one member of the group making physical contact with the deer and slowing it down enough for other group members to assist in dispatching it. Our observation supports this idea and suggests that Coyotes can use howling as an effective means of coordinating social activities such as the hunting of large prey.

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Book Reviews

Zoology

Fish of Alberta

By Amanda Joynt and Michael G. Sullivan. 2003. Lone Pine Publishing, Edmonton, Alberta. 176 pages. $18.95. ISBN 1-55105-191-5.

This book is a popular account of the 54 established and 11 more rare fishes of Alberta. It consists of Acknowledgements, Foreword (by J. S. Nelson, the expert on fishes of Alberta), Reference Guide, Introduction, Keys to the Fishes, Species Accounts, Size Comparisons, Other Alberta Fishes (the rarer species), Glossary, Checklist, Selected References, Further Information, Index of Scientific Names, Index of Common Names and About the Authors. These are mostly self-explanatory. The Reference Guide is a colour pictorial summary of each of the 54 species while Size Comparisons show the fish in relation to a loonie or a page in the book. The Glossary, Selected References and Further Information sections are short but give some additional sources and explications of terms. Schreckstoff is misspelled and the term "alarm substance" is more user-friendly. Laterally compressed is a tautonym, as compressed means flattened from side to side. For a more complete listing of terms used in ichthyology see www.briancoad.com.

The ichthyofauna includes 16 families with minnows (Cyprinidae) having 17 species, 3 introduced; trouts (Salmonidae) 16 species, 6 introduced; and suckers (Catostomidae) 7 species. Other families are lampreys, sturgeons, mooneyes, bullhead catfishes, pikes, trout-perches, cods, livebearers (2 species introduced to the Banff hot spring marshes), sticklebacks (1 introduced), sculpins, sunfishes (introduced), perches and cichlids (1 introduced to the Banff marshes).

The Introduction has information about identifying fishes, the lives of fishes, adaptations to life in water, the underwater world, drainage basins of Alberta, top Alberta fishwatching sites and fishwatching ("not yet a popular sport"), history of fishes and conservation issues. Key words are in bold text and some, but not all of these, have illustrations. One illustration, of Bull Trout and Walleye larvae used to explain reproductive strategies, is confusing in that these two distinctive species have the same larva illustrated.

The Species Accounts comprise two pages for each established species, in landscape orientation. This requires some twisting for reading introductory and other sections that have a standard orientation. Nonetheless, the landscape arrangement enables the fish illustrations to spread across the broadest reach of the page. Each Account has an introductory section, Viewing Tips (localities and habitats where the fish can be seen), Feeding, Spawning, Other Names, Did You Know? (an anecdote or interesting factoid), ID (identification characters), Similar Species, Status, Habitat, Length and Weight, the colour illustration and a colour, shaded distribution map.

Generally, the book is a good, popular treatment of this fish fauna written in a readable style that is not as dry as more scientific accounts. Some errors occur, perhaps as a result of this style or perhaps from the more pedantic viewpoint of the reviewer; e.g., in the Longnose Sucker account pharyngeal teeth are said to be in the mouth which could mislead the reader into thinking these throat teeth are readily visible.

The definition of "fish" and "fishes" is given on page 10 in the Introduction, fish being a single individual or more than one individual of a single species while fishes refers to more than one species. Curiously, the book is wrongly titled. The Reference Guide has a colour code for groups of species but since these colours are various shades of green and blue, they do not lend themselves to a ready means of locating species groups.

The fish illustrations are positioned with the head to the right, not a problem for most users, but somewhat disconcerting to those familiar with most fish books where traditionally the head faces left. The colour illustrations lack the details that can be included on line drawings, so certain critical features are not always visible. The illustrations have streaks of white meant as highlights but in some specimens look like a colour pattern.

Scientific names are given for all species and are accurate and, although *Stizostedion* may now be correctly *Sander*, the decision to leave it as the more familiar North American genus is probably apposite for information retrieval. Conversely, the Arctic Lamprey is given its newer name, *Lampetra camtschatica*, which is less well known than the older version, *L. japonica*, which is not mentioned and would inhibit search for information in other books. Common names are standard and include the Northern Pikeminnow, although its former name Northern Squawfish was not so much an "unpopular" designation as a derogatory one.

Despite the minor criticisms outlined above, this book is a good introductory guide to Alberta's fishes. Alberta seems well served in this respect with Nelson and Paetz's earlier book (1992). The older work provides a more detailed account of the fish fauna and may be more suited to the serious student of Alberta's

fishes – there is an extensive list of references (24 pages compared to only 11 references in Joynt and Sullivan). The book reviewed here has accounts for 65 species while Nelson and Paetz have a more complete analysis of 59 species and a further 29 species recorded as rare or doubtful for Alberta.

Literature Cited

Nelson, J. S., and **M. J. Paetz.** 1992. The Fishes of Alberta. The University of Alberta Press, Edmonton and the University of Calgary Press. 2nd Edition, 437 pages.

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Sharks

By Andrea and Antonella Ferrari. 2002. Firefly Books, Toronto, Ontario. 256 pages. $24.95. ISBN 1-55209-629-7.

Sharks are the most popular of fishes for publications as people seem to have a fascination for organisms that can eat you (although more sharks are killed by people than the reverse). This is one of many that have appeared on this topic.

Despite its title, the book covers the appearance and behaviour of 120 species of sharks and rays. Coverage is therefore not complete as sharks and rays number over 1000 species (as the Foreword states), the aim being to give an overview of the main groups by selecting typical and unusual or fascinating species. Four species of rabbitfishes (out of about 31 species in the Chimaeriformes) are also mentioned.

The book has an Introduction of 77 pages with descriptions of anatomy and biology. Three pages are devoted, deservedly, to explaining the ampullae of Lorenzini, an important feature of shark anatomy and biology, first discovered by an Italian scientist in the seventeenth century and, surely by coincidence, this book has Italian authors and is a translation from an Italian version. This is followed by how to avoid sharks, how to assist them (by not eating them or buying shark teeth), marine organisms more dangerous than sharks (mostly venomous sea snakes, cone shells, sea urchins, jellyfishes and fishes, but also fish that bite divers enthusiastically), and personal accounts of shark encounters. The Entries section describes the sharks, rays and rabbitfishes (153 pages), the Appendices (17 pages) give a Classification of Sharks (but not rays or rabbitfishes), an Index, Bibliography and Websites (each a page long), and Photographic Credits. The websites "Catalog of Fishes" and "FishBase" are not quoted, although these give entry to much of the names, biology and literature on sharks and rays world-wide for the more serious student. There are pictorial keys to the shark and ray orders but not any for families or species so the book cannot be used, nor is it meant, as a field guide.

The Entries section describes each selected species, allotting half to two pages per species. There is an annoying symbol system at the top of each account to indicate when the shark is active and its danger level with respect to humans. This information could easily have been included in the text. A distribution map is given but at 1 × 2 cm can only convey a general impression of where these sharks and rays are found. The map for the Bluntnose Shark is inaccurate, for example, showing it in Canadian Arctic waters when it was first caught at its northern limit in Nova Scotian waters in 1989 (Gilhen and Coad 1991). The common and scientific names are given but the author and date of the scientific name is always in parentheses (here and in the Classification of Sharks). The authors (or text editor?) seem not to be aware that parentheses are only used when the species is placed in a genus other than the one it was originally described under. The text comprises the Family to which the shark or ray belongs, Range, Habitat, Size, and Habits. All parts of the book are richly illustrated with colour photographs, over 450 in all.

Despite the comments above, this book is a good general introduction to sharks and rays. It is lavishly illustrated, as all such books must be, of a convenient size, and with a reasonable price.

Literature Cited

Gilhen, John, and **Brian W. Coad.** 1991. The bluntnose sixgill shark *Hexanchus griseus* (Bonnatere, 1788), new to the fish fauna of Atlantic Canada. Proceedings of the Nova Scotian Institute of Science, 39 (1989): 75-77.

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In Search of the Golden Frog

By Martha Crump. 2002. University of Chicago Press, 5801 Ellis Avenue, Chicago, Illinois 60637 USA. xiv + 298 pages, Cloth US$27.

Any young person thinking of taking a degree in one of the biological sciences, particularly if they plan to become a field biologist, should read this book. The author, currently Adjunct Professor of Biology at Northern Arizona University, chronicles her life from her postgraduate work in 1968 through various projects to 1998. The book concentrates on the field programs that are the real love of Professor Crump's life. Her main interests are reptiles and amphibians, but her passion is frogs.

Taking advantage of an opportunity offered by her discerning professor, she joins a team going to the Amazon section of Ecuador. From this exposure which

reinforces her desire to work in the field, she returns repeatedly to work in South America. Her narrative includes her excitement at being a scientist and making discoveries to contribute to her profession. She also chronicles some of the problems she encounters. These do not include frightening encounters with large or dangerous animals. The hazards fall into two categories. The small pests, mosquitoes, chiggers, chigoes, bot flies and ants, causes plenty of discomfort. But it is the large pest, humans, that causes the greatest levels of concern. She notes the ordinary people are by and large, friendly and helpful. It is the bandits, police, military, industrialists and rioting natives that disrupt her life.

As I started to read this book I became very disconcerted. In the past few years I have looked for amphibians and reptiles in tropical jungles on many occasions. My success rate is very low. The author travels to the same locations in South America and immediately starts finding many individuals of multiple species. My estimation of my frog finding prowess dropped page by page. By the time the author reaches the 1990s, however, her success rate has plummeted. By 1996 she says "we hug and screech with excitement" on finding one frog. I realize that my lack of success is due less to my incompetence than to the rapid loss of frogs in my lifetime. This is even more depressing. When I go to Monteverde next spring I have little hope of seeing the fabulous Golden Frog. On 7 April 1987 this author saw "over one hundred dazzling bright golden toads" at one small pool at Monteverde.

The author also deserves another accolade for, while she is pursuing her scientific research, she is also being a parent to two children. I was delighted with the way she involved them in her work and gave them opportunities to broaden their knowledge. This may have made her life harder and certainly caused her concerns, but I am sure these children will benefit.

So if you want to find out about the life of a field researcher read this entertaining book. Follow the trials of first reaching the field locations using often unreliable local transport. Join in meals that are good, bad, or bizarre. Meet local people, many of whom care greatly about their environment. Find out how a scientist collects data and uses it to create a new understanding of our planet.

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Conversations with an Eagle

By Brenda Cox. 2002. Greystone Books, Douglas & McIntyre Publishing Group, 2323 Quebec Street, Vancouver, British Columbia V5T 4S7. 261 pages, paperback.

This is a story of dedication to an eagle rather than conversations with one. Brenda Cox was a volunteer worker at a raptor rehabilitation centre south of Vancouver (Orphaned Wild Life – OWL), and became enthralled with raptors of all kinds. Her special interest was a Bald Eagle, which was three months old when it arrived at the Centre, and her book describes the trials and tribulations of her efforts to train Ichabod so that she could be used in the OWL education programme.

In the course of the story there are passages describing the methods used to rehabilitate owls, hawks and eagles. When the eagle was still young its behaviour was typically fearful, but the bird became more and more aggressive towards Cox, such that she had to stand against a pillar armed with a household mop to protect herself if she was attacked. In spite of the danger, she persisted in training the bird to come to her gloved arm, and eventually it obeyed three commands: Up, Wait and Off. But it was always uncertain whether the bird would cooperate or not on any given day. She enlisted the help of expert falconers in the Vancouver area. They were doubtful whether a Bald Eagle could be reliably trained, though they helped and advised her. Bald Eagles have seldom been trained successfully, while Golden Eagles have been used by falconers in many parts of the world. Cox was able to train the eagle such that she could take her from her cage to a perch in a field, using jesses and a stout leash attached to her waist, but there were increasing dangerous attacks which inflicted talon wounds on Cox's head, arms and feet.

After several years, the OWL management decided that they would never be able to use the bird in their programme and asked Cox to remove it from the facility. In its new quarters, shortly afterwards the bird developed a lung disease and was euthanized. Cox's dedication to her volunteer job is remarkable since, in the course of the seven years, she did not have steady employment or reliable housing or transportation. Since Ichabod's death, she has now found a steady career: as a conductor with British Columbia Rail, and watches the wild raptors along the railway lines. Her story would appeal to someone interested in raptor rehabilitation methods and the lore of falconry.

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North American Owls, Biology and Natural History, Second Edition

Paul A. Johnsgard. 2002. Smithsonian Institution Press, Washington. 298 pages, 42 colour plates, 69 multi-figured black-and-white maps and sketches, 10 tables, 2 graphs. $46.25 Canadian, hardcover. US$27.95.

Although Dr. Johnsgard's long history of producing books about birds is well known, his entry to the "owl-lover's camp" is more recent. The first edition of this book came out in 1988 and immediately became the standard reference book for owls of the United States and Canada. For the second edition, 14 years later, Johnsgard has added twelve species of Mexican owls and nearly doubled the number of references (although, contrary to convention, many of the recent references are not mentioned by name in the text!). Extremely few changes have been made to the excellent introductory chapters, but this leaves them less up-to-date than the individual species accounts. Often he cites the authors of the *Birds of North America* account, rather than the original observers who merit the credit; an example is Gottfred and Gottfred's new information concerning courtship and copulation of the Great Horned Owl, published in *Blue Jay* in 1996.

The strengths of the first edition have been maintained: the introductory chapters and species accounts are neatly arranged; maps of each species' range are detailed; Johnsgard's pen-and-ink sketches of aspects of behaviour are delightful; the colour plates and photographs are superb. Johnsgard writes well, but in a few occasions new material has been interjected clumsily, marring the previous smooth flow of information in the first edition.

Some compromises were necessary. To make room for the twelve Mexican species, detailed descriptions of plumage have been omitted in this second edition. This does not excuse three sloppy errors. Johnsgard tells of the Pygmy Owl range extending altitudinally to 37 000 meters in Mexico, whereas the quoted source gave a credible 3700 m. A paper by Jack Holt on Great Horned Owls in the Cincinnati region is credited to Denver Holt. Thirdly, when Johnsgard withdrew his overdrawn sketch of the "false eye-spots" on the back of the Northern Pygmy Owl's head from the first edition and substituted a more realistic sketch of the Ferruginous Pygmy Owl in the second edition, he failed to change the figure numbers in the text to comply with this change.

These minor caveats aside, this masterful second edition will be welcomed by owl enthusiasts around the world, and should be purchased even by those owning the first edition. It is written more for the scientist than the amateur, but, by identifying deficiencies in our current knowledge, this book should offer possibilities for future study by graduate students and others who love our night-time friends.

Johnsgard's exquisite sketches, 10 coloured paintings of owls by Louis Agassiz Fuertes, and 31 fine colour photographs, including nine of Mexican owls, make this an unusually attractive book. Buy it!

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The Mountain White-Crowned Sparrow: Migration and Reproduction at High Altitude

By Martin L. Morton. 2002. Studies in Avian Biology Number 24. Cooper Ornithological Society, Camarillo, California. 236 pages, 8 colour plates, pencil illustrations heading each chapter. U.S.$27.

The northern limit of the distribution of the Mountain White-Crowned Sparrow (*Zonotrichia leucophrys oriantha*) extends slightly into southern British Columbia, Alberta and Saskatchewan. Its main breeding range is in mountainous regions of the western U.S. Here in Waterton Lakes National Park we're at the contact zone between *oriantha* and *Z. l. gambelii*.

Morton's 25-year study of *oriantha* in the Tioga Pass area of California's Sierra Nevada ranks with P. J. Greenwood's lengthy study of the Great Tit (*Parus major*) in Europe and G. E. Woofenden's work with the Florida Scrub Jay (*Aphelocoma coerulescens*) in showing the value of continuous long-term field investigations in advancing a broad spectrum of ideas and hypotheses in avian biology. Morton's focus is different, however, in emphasizing physiology more than behaviour or ecology. In 1968, Morton recognized that there were significant gaps in knowledge of migratory passerines on their summering grounds, especially in mountains where large variations in environmental conditions occur.

As my interests lie more with natural history, life history data (age at maturity, number, size and sex ratio of offspring, dispersal and survival rates) and ecological factors than with physiology, I found Morton's first three chapters on Migration Arrival, Social System and Behavior, and Demography of most interest (although a bit disappointing at only one-quarter of the book's pages). The dynamics of arrival of *oriantha* varied greatly from year-to-year depending upon the amount of remaining snowpack and the frequency of spring storms, as well as by age and sex. By trapping and colour-marking individuals, the researchers found that older males (age 2+ years) generally arrive earliest, followed by one-year-old males, older females and one-year-old females. Throughout the monograph, Morton does an excellent job of analysing observed data in terms of costs and benefits, and ecological fact-

ors, in this case, suggesting that older, experienced birds knew the migration route and recognized the breeding area once they reached it, even it if was snow-covered.

Morton's efforts over many reproductive seasons made it possible to measure mate fidelity, age of mates, frequency of polygamous pairings, agressive behaviours, and the functions of vocalizations, in addition to the usual study of territory establishment, pairing, and between-year breeding dispersal.

Although I expected the chapters on Gonadal Condition, and Body Size and Body Condition, to be of less personal interest, Morton's explanations of the connections between physiology and behaviour, and description of the role of environmental cues in annual cycles made these sections much more interesting than anticipated. Environmental factors are either ultimate (e.g., availability of an adequate food supply, predation pressure, weather patterns) or proximate (e.g., photoperiod, ambient temperature) in their effects on the timing of reproduction.

Nest history (chapters 7, 8, 9 and 10 on Nests and Eggs, Nestlings and Fledglings, Nest Failure and Reproductive Success, respectively) provided reliable information on physiological and behavioural responses of breeding birds to environmental variation, often to the level of individuals because of Morton's use of marked birds. And the researchers determined that the snowpack, because of its effects on nesting schedules and nest locations, was a stronger environmental factor on reproductive success than sub-freezing temperatures or summer storms. *Oriantha* exhibited plasticity in responding to snow conditions by abandoning ground-nesting and building their nests in elevated sites when there was more snow, as opposed to Hermit Thrushes (*Catharus guttatus*) or Dark-eyed Juncos (*Junco hyemalis*), which nested on the ground no matter what the environmental conditions.

Morton's study shows that challenges posed by environmental variation often can be met with existing behavioural and physiological responses; adaptation occurs through flexibility rather than through acquisition of new abilities or mechanisms.

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Seabird Bycatch: Trends, Roadblocks, and Solutions

Edited by Edward F. Melvin and Julia K. Parrish. 2001. University of Alaska Sea Grant AK-SG-01-01, Fairbanks, Alaska. viii + 206 pages. U.S.$20.00.

The incidental catch of various water birds and other aquatic organisms (e.g., turtles, sea otters, porpoises, seals) in fishing nets has long been of concern to naturalists for conservation reasons and to the fishing industry for economic reasons. However, until recently this issue has been on the "back burner" compared with more pressing and widespread environmental problems. The advent of intensified fishing efforts, huge factory ships, and collapsing fish stocks have elevated this bycatch into both a major international environmental issue and a serious economic problem. This book, essentially the proceedings of a symposium, presents a recent update on the extent of the problem in marine waters, world-wide, evaluations of several proposed solutions as they apply to specific fisheries and problems that have yet to be overcome.

The editors begin the book with a short preface that outlines the history and extent of the problem, especially since it was identified as a major conservation issue in the early 1970s. The first full chapter is a synthesis, also by the editors, of a symposium organized by the Pacific Seabird Group in Blaine, Washington, in 1999. The synthesis summarizes the complexity of the problem, "roadblocks" in the way of solving it and guidelines to possible solutions. The remainder of the book consists of nine peer-reviewed, scientific papers (eight of which were presented at the symposium) and seven abstracts. Two of the papers were reprinted from recent (1999 and 2000) scientific journals. One paper, by John Cooper, John Croxall and Kim Rivera outlines the complexities of international efforts to reduce bycatch through research, local and international regulations and cooperation among scientists, the fishing industry and conservation groups. An afterword by Craig Harrison graphically illustrates the complexity of the problem by outlining the political and practical difficulties of coordinating efforts to reduce bycatch in the sockeye salmon fishery in the "shared waters" of British Columbia and Washington, where two federal, one provincial and one state government share jurisdiction with "21 Native American tribes" [a total that applies only to Washington and omits the first nations of British Columbia].

The rest of the papers and abstracts document the extent of the bycatch in specific fisheries, results of various experiments to reduce bycatch, and attempts to measure the impact of specific fisheries on specific populations of birds. As some seabirds spend non-breeding times thousands of kilometers from their breeding sites, measuring the effects of a specific fishery on a particular breeding population is very difficult, especially as many seabirds are long-lived and don't breed every year. Moreover, fishing in a given area may affect some species much more profoundly than their close relatives (for example, effects of bycatch on Black-footed Albatross populations are much more significant than on Laysan Albatrosses) and may affect different age groups differently (for example, juvenile Black-footed Albatrosses are caught at a higher rate than adults). Research presented in this volume from the Atlantic, Pacific and Southern (Antarc-

tic) oceans shows that modifications to fishing gear (weights, design, visual and acoustic alerts), timing of fishing (daily and seasonally) and other techniques can reduce bycatch substantially without substantially reducing the take of target species, but that these modifications have different effects on the rate of bycatch of different species and sometimes of a given species in different areas, different times of the day or different seasons. Banding continues to be helpful in sorting out the origins of birds caught in specific fisheries, while higher tech tracking devices and research on genetic markers are also starting to improve our knowledge of the complexities of movements by these highly mobile species. Albatrosses receive the greatest amount of attention, but data on various other "tubenoses," alcids, larids and some marine mammals are also presented.

Canadian content figures prominently in this book. A 1972 paper by Canadian C. Eric Tull and co-authors on the magnitude of Thick-billed Murre mortality in Greenland fisheries is credited (page v) in drawing attention to the significance of fisheries in seabird population declines, and international legal efforts to reduce bycatch in longlines stem from a resolution at a 1996 meeting in Montreal of the World Conservation Congress of the World Conservation Union (page 11). Data from British Columbia are included in a genetics (DNA) study of the breeding locations of Common Murres entangled in fishing nets in Washington's San Juan Islands and Puget Sound (pages 125-127) and in an abstract (pages 191-192) on seabird avoidance experiments in northern Pacific waters. Other papers and abstracts on observations and research in Alaskan and Washington waters involve populations of birds that spend portions of their lives in British Columbian waters. Research from Atlantic coast provinces and British Columbia are cited frequently.

This book provides a useful compilation of recent developments on a complex issue, with plenty of information on legal (national and international)/political aspects, recent research on seabird movements, recent research on genetics of seabird populations, and practical tests of various techniques under a variety of conditions in a variety of waters. The literature cited sections provide numerous additional references for those requiring further information. The book should be on the library shelves of any researchers, government agencies and non-government conservation and scientific organizations studying seabird biology and/or the conservation of seabirds. Errors appear to be few – the reference to Wilson et al. (1985) cited on page 116 is not listed in that chapter's literature cited section, which includes two references that don't appear to have been cited. However, since most of the chapters are written as scientific papers, some may be too technical for some readers. The review by Cooper et al. of legal and quasilegal aspects of the issue provides a valuable reference compendium, but is so riddled with acronyms that I found myself wishing for a glossary. I also hope that the seven abstracts at the end of the book are expanded into full papers somewhere. As valuable a contribution as the book is in itself, this volume will undoubtedly also stimulate more research that will require another update before long. Such an update could usefully also include papers or chapters on aquatic bird bycatch of fisheries on inland waters, such as those of the Great Lakes, several large prairie province lakes and similar lakes on other continents.

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The Life of Mammals

By David Attenborough. 2002. Princeton University Press, New Jersey. 320 pages, U.S.$29.95.

As the latest edition in the BBC "Life" series combining television and print media, the book on mammals is nicely illustrated with a good selection of colour photographs that closely follows the engaging text by David Attenborough as he presents interesting stories on these fascinating animals. The first chapter, "A Winning Design", starts off with the ability of mammals to adapt to different environments on earth, including the harsh arctic conditions where lemmings live year round. After describing some basic characters of mammals, such as hair and the production of milk, there is a general introduction to the origin and evolution of this group of warm-blooded organisms. The chapter finishes off with two early mammalian radiations that cover the egg-laying monotremes and the marsupials, which give birth to under-developed young.

The remaining nine chapters deal with the placental eutherian mammals but instead of continuing to describe them by scientific groups the format switches to artificial categories such as diet and habitat. This unnatural classification seems awkward at times with bats, which people can readily identify with, split into two separate chapters, "Insect Hunters" (curiously including vampire bats) and "Life in the Trees" (although some insect-eating bats also live in trees). There was a missed opportunity to educate readers in scientific classification and evolution while still entertaining them with a plethora of amazing natural history stories.

Primates get star billing in the book with the last two and a half chapters devoted to this charismatic order of mammals. Although the higher-level taxonomy (or common names employed) is not current, it begins

with prosimians as an early branch of the primates. The latest view is that this is not a natural group because, for example, tarsiers are more closely related to monkeys and apes, as alluded to but nonetheless still included in the chapter with lemurs. The other primates are grouped to cover the new and old world monkeys, and ending with the gibbons and great apes, including a branch for humans. The last half chapter concentrates on both physical and social anthropology from the first evidence of bipedal locomotion to cultivation and civilization.

The book is definitely aimed at a general but knowledgeable audience with an interest in nature and mammals. I am sure, however, that practising biologists will still find a few facts new to them in their non-specialist group because the background research is relatively good. It was nice to see some recent scientific hypotheses on mammalian evolution making it into the book such as the close relationship between whales and hippopotamuses. But some other emerging ideas based primarily on molecular data did not, including the association of bats with carnivores, ungulates and whales, as opposed to insectivores, or tree shrews, flying lemurs and primates.

My criticisms are mostly biologically oriented because the book is attractively presented with most photographs of good quality and information well written. But there should be more books that combine current scientific research with an explanation of the deeper implications or processes involved for wider distribution to the general public looking for meaningful substance beyond the usual cursory facts.

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Geographic Variation in Size and Shape of Savannah Sparrows *(Passerculus sandwichensis)*

By James D. Rising. 2001. Studies in Avian Biology Number 23. Cooper Ornithological Society, Camarillo, California. 65 pages. U.S.$7.

The newer field guides, such as *The Sibley Guide to Birds*, occasionally describe and illustrate subspecies of birds, usually based on differences in plumage or soft parts. The "bander's bible", Peter Pyle's *Identification Guide to North American Birds*, includes wing and tail measurements to help banders identify birds to the subspecies level – for example, he discusses 14 subspecies of the Savannah Sparrow. But have you ever wondered *why* these differences exist in the natural world?

Rising does and asks two questions in this regard: Why do features such as body size, wing length, or bill size and shape differ across a species' range? and, if these differences reflect adaptations to the different environments to which the species is exposed, what are the selective factors that have caused them?

One of the classic explanations for geographic variation in size is Bergmann's Rule, which holds that individuals of a species (vertebrates only) from colder areas are generally larger-bodied than individuals from warmer areas. Allen's Rule takes this one step further, stating that within such species, individuals from colder areas will have smaller appendages relative to their body size than individuals from warmer areas.

Rising asked his questions of the Savannah Sparrow, which is one of the most wide-spread songbirds in North America. He describes and quantifies geographic variation in the species throughout its breeding range, from Alaska to the Maritimes to central Mexico, and relates trends in phenotypic variation to environmental variation.

He found some clinal variation in size of Savannah Sparrows, with birds from the northeast being slightly larger than those from the west, and birds in cool, moist areas were larger than those where it is hot and dry. But the species overall did not seem to follow Bergmann's Rule; rather, measures of summer temperature and precipitation explained well the patterns of size variation. His more significant find, though, was that birds were larger on islands than on mainland sites, whether in the Aleutian Islands, Alaska, or on Sable Island, Nova Scotia. He speculates that the long, cool, moist summers on these islands results in a predictable and fairly rich food supply. This, combined with the rather long breeding season, allows multiple broods and perhaps enhanced competition for high quality territories. This competition for either food or territories might select for larger body size.

Rising ends with some taxonomic comments, coming out on the side of the "lumpers". He sees no virtue in naming subspecies where the only way they can be reliably separated is by locality. He suggests recognizing only two subspecies of non-saltmarsh Savannah Sparrows, *P. s. sandwichensis* (large size) and *P. s. princeps* (large and pallid), whereas the nine saltmarsh subspecies seem to be clearly separable by morphological characters. This is in contrast to the 17 subspecies currently recognized by the American Ornithologists' Union.

Rising's work relies on Principal Components and Discriminant Functions analyses, which, although I found it a little heavy going, was well presented sequentially and a good example of the use of these techniques for morphometric comparisons.

It will be interesting to watch in the coming years how Rising's thorough morphological studies interact with genetic analyses in assessing variation and the subspecies of Savannah Sparrows.

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Warblers of the Great Lakes and Eastern North America

By Chris Early. 2003. Firefly Books Ltd., 3680 Victoria Park Avenue, Toronto, Ontario, M2H 3K1. 131 + pages. Cloth $24.95: paper $16.95

Sparrows and Finches of the Great Lakes and Eastern North America

By Chris Early. 2003. Firefly Books Ltd., 3680 Victoria Park Avenue, Toronto, Ontario, M2H 3K1. 128 + pages. Cloth $24.95: paper $.16.95

These books are an expansion and revision of two earlier books by Chris Early (*Warblers of Ontario* and *Sparrows and Finches of Ontario*). They both follow the successful format of the earlier books. Each species is shown in two to five photographs (Warblers) or two to seven photographs (Sparrows). The actual number of photographs for each species depends on how variable the bird's plumage can be. A short introductory note is followed by descriptions of the key plumage characteristics and other relevant details. A 5 × 3 cm map of America shows the summer and winter ranges.

"Warblers" covers 37 species plus one hybrid in some detail. An additional seven vagrant species and one race (the Yellow-rumped "Audubon's" Warbler) are covered by brief comments and a single accompanying photograph.

"Sparrows" includes 25 species covered in full and 20 vagrant species. In addition to the North American sparrows (buntings) this volume includes longspurs, finches, grosbeaks, crossbills, snow bunting and house sparrow.

There are two features used by this author that will make this book particularly valuable to beginners. The first is called a cheat sheet and lists all the birds in groups according to a key characteristic – such as an unstreaked breast. The birds are further grouped by a second characteristic such as a breast spot. The second, and even better innovation, is a series of comparison tables. These consist of a set of photographs with birds in similar poses. The page is arranged to show the most similar birds close together. For example, there are three Common Redpoll photographs immediately above three equivalent Hoary Redpoll photographs. Similarly, all the rufous-capped sparrows are on one page. I think the arrangement of the warbler comparison table is very clever. Here the Mourning Warbler photograph is adjacent to a Connecticut Warbler photograph. In turn, the Connecticut is above a photograph of a Nashville Warbler, which in turn is above a Northern Parula. All four birds share similar combinations of colour and cause confusion to the novice. This arrangement allows for easy comparison, either up and down or across the rows. For the warblers there are tables showing the spring and fall plumages. These features are on fold-out sheets at the end of the book, making them quickly available in the field. At the front of the book is a seasonal distribution list for Point Pelee National Park. Using line thickness the author also indicates the abundance of each species. I find such distribution lists to be extremely useful.

These then are two small, portable books that deal with birds that many find difficult to identify. The text is well written. The photographs are both beautiful and illustrative. Any one who needs help with the species covered will find these books a tremendous help. Perhaps we can encourage the author to write a third book on shorebirds.

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Birds of the Yukon Territory

Edited by P. H. Sinclair, W. A. Nixon, C. D. Eckert and N. L. Hughes. University of British Columbia Press, Vancouver, British Columbia.

My appetite for a long-overdue return trip to the Yukon has been incredibly whetted! This book is not just an atlas, but also a coffee table book, a very useful bird reference, and a source necessary for a planning a trip to the Yukon. This book has stunning photographs throughout, and not just of birds, but of dramatic scenery (i.e., habitat shots) that will make birders and non-birders alike think, "I must go there."

Prior to the species accounts, there are chapters covering the environment, aboriginal use of birds, conservation, history and a month-by-month overview of birdlife. There is also a short chapter outlining the data management for the more than 160 000 records that were used.

Each species account spans one to three pages. All species are illustrated by a line drawing and at least one, sometimes several, colour photographs; frequently, there is a very good habitat shot as well. Each account also has a distribution map, and a histogram outlining the number of database records for each week of the year. The base layers of the maps show major roads and rivers as well as ecozones; I would have liked to see the dominant population centers marked as well though.

The text is thorough and reads well. All the expected sections are there (distribution, nesting, habitat…), and, where appropriate, a section on aboriginal use of

the bird is included. Several appendices and a 600+ reference list end the book.

The items that bothered me were few, and mostly minor. Noteworthy was the absence of birding essays, a feature I first saw in *Birds of Delaware*, and thought added spark to the thick reference book. Page numbers were located in the most irritating choice possible, along the inner margin of each page, thus not permitting a rapid flip-through while searching through this 600 page book. The final, and dare I say incomprehensible feature of the book was the uninteresting and out of focus (soft focus?) cover shot of the Territorial bird, the Common Raven. People do judge a book by its cover, rightly or wrongly, and in a book with hundreds of stellar shots, I remain baffled as to why that particular shot was chosen to be most people's first impression of the book.

Overall though, this is a very, very good book, and a must-have for people interested in the birdlife of the North.

RANDY LAUFF

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Literature Cited

Hess, G. K., R. L. West, M. V. Barnhill III, and **L. M. Fleming.** 1999. Birds of Delaware. University of Pittsburgh Press. 635 pages.

BOTANY

Wild Flowers of the Yukon, Alaska & Northwestern Canada, 2nd Edition

By John G. Trelawny. 2003. Harbour Publishing Co. Ltd., P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 224 pages. $24.95.

The first edition of this wild flower book was published in 1983 and I reviewed it in 1984. The layout in this new volume is much better. The type is larger and more spaced on a purely white paper and is wrapped around the absolutely beautiful colour photographs.

Many of the pictures of the 332 species treated are the same as those in the first edition but the more modern reproductions and paper have made them shine. The descriptive text for each species has been only slightly revised. The surrounding text includes Acknowledgments, an easy-to-read map, an Introduction, an Illustrated Glossary, a Key to Species using Flower Colour and Shape, Photo Credits, Bibliography, an Index, and a list of Additional Field Guides from Harbour Publishing. This is a most interesting and delightful book for anyone living in, visiting or planning to visit this wonderful area.

WILLIAM J. CODY

Biodiversity, Program on Environmental Health, Agriculture and Agri-Food Canada, Wm. Saunders Building, Central Experimental Farm, Ottawa, Ontario K1A 0C6 Canada.

Wild Flowers of Field & Slope in the Pacific Northwest

By Lewis J. Clark. 2002. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0. $9.95.

Wild Flowers of Forest & Woodland in the Pacific Northwest

By Lewis J. Clark. 2003. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0. $12.95

Wild Flowers of the Mountains in the Pacific Northwest

By Lewis J. Clark. 2003. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0. $12.95.

These three books contain absolutely beautiful colour photographs. The photographs are numbered sequentially and each one has a marker [×0.5] to indicate its size. Each is accompanied by a printed paragraph with the common and scientific names, a detailed description, together with the habitat and range, and a number to indicate its sequence in the book. There are 108 in the first book, 100 in the second and 106 in the third.

There is a four- or five-page interesting introduction at the front of each book and an index, glossary and a list of Additional Field Guides available from Harbour Publishing at the end. There are most interesting pictures on the front covers of each book. On the back covers there is a note about the author, Dr. Lewis J. Clark, together with a map of the Pacific Northwest on which there are shaded areas depicting where the wild flowers can be found. All are elegant.

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MISCELLANEOUS

The Canoe: A Living Tradition

By John Jennings. Firefly Books, Toronto. 272 pages. $59.95.

There could hardly be a more poetic way to explore the natural world than by canoe. While not all observers of natural history are canoeists, most canoeists have respect for and curiosity about nature. Indeed, a loon's call or the slap of a beaver's tail, accompanied by the quiet burbling of a canoe's wake, has served as an introduction to the contemplation of nature for countless North Americans.

The Canoe: A Living Tradition is, in a sense, a natural history of traditional North American watercraft. Included in this beautifully illustrated, coffee table-sized book are chapters dedicated to the history and construction of birch bark and dugout canoes, as well as skin kayaks and umiaks (large, open vessels from the Canadian Arctic). This book also discusses the influence of canoes on the fur trade and the settlement of northern North America, as well as the development of recreational canoes and the preservation of canoe history in more recent times. A respected expert writes each chapter on the type of craft or historical context being discussed. This makes for inconsistent writing at times, but also gives the book an authority that would not have been achieved by a single author. I found that the technical details about the dimensions (i.e., width and length, etc.) of canoes a bit repetitive. On the other hand, the documentation of these measurements may be valuable in the future. As John Jennings notes in the first chapter, the original canoe designs of several First Nations in North America have been erased without a trace, a poignant reminder of the terrible loss of traditional knowledge that continues to this day.

While the book brilliantly covers the historical context of canoeing and canoe building (over the span of 230 pages), it pays scant attention to modern uses of the canoe (2 pages). After all, as the title suggests, canoeing and canoe building is a "living tradition". Canoeing is still one of the most elegant ways to explore nature and there are many fine canoe builders in North America currently manufacturing modern and traditional canoes from a wide range of natural and synthetic materials. It seems as though a chapter could have been devoted to recent developments in the design and construction of modern canoes.

The book gives a good overview of how birch bark and dugout canoes are constructed, including useful photographic illustrations; however, before you run out and start assembling materials, take heed: the information provided is insufficient for the "do it yourself" canoe builder. A noticeable shortcoming is the omission of information about the many resources available to those interested in building traditional birch bark and dugout canoes, as well as skin kayaks. For instance, while the book contains a photograph of a canoe built by César Nawashish, it fails to reference the excellent 1971 National Film Board film "César's Bark Canoe", which documents Nawashish's completion of a bark canoe with exquisite detail. Other contemporary builders of traditional craft have also produced thorough "how to" publications on building birch bark canoes and skin kayaks including David Gidmark, Robert Morris and Wolfgang Brink, which have not been referenced in this book.

While Adney and Chapelle's *Bark Canoes and Skin Boats of North America* will remain the bible of traditional canoe and kayak design, *The Canoe: A Living Tradition* is broader (literally and figuratively), more colourful and more accessible. It is simply irresistible for the canoe enthusiast. Its shortcomings are few and its design and production qualities are excellent. In summary, it is a valuable addition to the annals of canoe culture. Congratulations to John Jennings and the Canadian Canoe Museum for their fine work.

PATRICK WILLISTON

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A Passion for Wildlife: The History of the Canadian Wildlife Service

By J. A. Burnett. UBC Press, Vancouver, British Columbia. Hardcover. 331 pages, $27.95 paper, $85.00 cloth.

Anyone who is prejudiced against "civil servants" should read this book. The Canadian Wildlife Service, from its inception, has contained a cadre of dedicated scientists who work long hours, share their knowledge widely, and on occasion risk their lives for the sake of the environment. Burnett, an insider, tells the story of this valuable and generally cost-effective organization, beginning in 1916 with the five men who were involved in drafting and implementing, from the Canadian side, the Migratory Birds Convention Act. In 1918, Hoyes Lloyd was appointed as Supervisor of Wild Life Protection in Canada. Lloyd, in turn, appointed three Federal Migratory Bird Officers. The Dominion Wildlife Service (now the Canadian Wildlife Service or CWS) was founded on 1 November 1947.

Burnett follows a roughly chronological sequence, with 67 photographs. His writing skills introduce us to many interesting scientists and their achievements, without the inevitable plethora of names becoming objectionable. The footnotes list the main publications that resulted from extensive research. He covers objectively the lowest point in CWS history, the short but destructive reign of Suzanne Blais-Grenier as federal Minister of the Environment.

This excellent history will be of interest to most ornithologists, mammalogists and environmentalists, and will be a useful reference in every major library.

However, I must admit to being flabbergasted by the publication of this book by a reputable university press, without any mention, let alone acknowledgement, of the previous publication, with the identical title, and with 99 per cent of the text which filled one issue of *The Canadian Field-Naturalist* 113:1-214, January-March 1999. Readers of this journal do not need to buy the book; they already have a soft-cover version on their shelves.

What does the new version offer as compared to the unmentioned and unacknowledged version? An appropriate foreword by Janet Foster and a few new photographs have been added, but most are unchanged except that their quality has been improved and some have increased in size. Additions have been made to the following sub-chapters: "Seabirds," a paragraph about Tony Gaston's work on the Ancient Murrelet; "Shorebirds," two paragraphs on the Latin American cooperation in shorebird banding and mention of the Kees Vermeer Award now presented annually at Simon Fraser University; "Habitat Management," a paragraph on the purchase of Westham Island in the Fraser River delta; "Consolidation," two new paragraphs on wildlife policy changes; "Peregrine Falcon," Richard Fyfe's investiture into the Order of Canada on 26 April 2000; "Species Protection," a paragraph on the delays and rocky road of Bill C-5, the Canada Species at Risk Act, which finally passed on 11 June 2002; "A Work in Progress," four sentences of reminiscences by Rob Butler. The title of Chapter 5 has been improved from "Policy Implementation" to "Emergence of Environment Canada." A few small editorial improvements are evident, such as a change from "at the same time that" to "even as." Otherwise the two versions are almost word for word and paragraph for paragraph in the text and word for word in the index. Sadly, an opportunity to index each annual wildlife conference was not seized.

What has been deleted? A short biography of the author, Sandy Burnett; a short afterword by editor, Francis Cook, explaining the contributions to editing of the *Canadian Field-Naturalist* made by Harrison F. Lewis, C. H. D. Clarke, and A. J. Erskine; and a useful 31-page bibliography of major publications by CWS personnel, compiled by Erskine.

The *Canadian Field-Naturalist* exists to record and spread information of value, and contains a clear statement that copyright for this particular paper resides with "Her Majesty the Queen in Right of Canada" as stated in 113(1). However, I remain surprised that the author and the publisher appear, consciously or unconsciously, to have chosen to withhold information about this material having previously appeared in the very scientific journal in which this review is now appearing.

C. STUART HOUSTON

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Copies of CFN 113(1) are available for $10.00 from the Business Manager.

Birding on Borrowed Time

By Phoebe Snetsinger. 2003. ABA Inc. Box 6599, Colorado Springs, Colorado. 307 pages. Paper US$19.19.

I never met Phoebe Snetsinger. In fact I have only a vague recollection of hearing her name. I was surprised at her sudden prominence after she died. Now I have read her book and I understand.

I expected someone who saw over 8000 species to be the typical "combat " birder; a person who relishes getting the tick on her checklist above everything else. Phoebe Snetsinger was not a combat birder; she was a true birdwatcher. She insisted on really seeing and recording the birds she counted. She did not include those flits that zip into view for an instant and are identified by the local guide. I have seen combat birders joyfully tick off such birds on their list and immediately move rapidly on in search of their next "lifer." Indeed the author did not seem to be truly competitive until after her 7000th bird species and in line for the *Guinness Book of Records.* She ceased being competitive after achieving the world record at her 8000th species of bird.

Her book is the account of her travels in accumulating this incredible total, and the joy she had in seeing all of these birds. She was a focused, energetic and hardworking individual who took her birdwatching extremely seriously. She studied her target species long before trying to see them. She kept copious notes on what she saw. I agree with this approach and try to use it myself. I do not understand why people pay so much money and effort to go to a prime nature locale, yet do not do their homework.

Spurred into action by the threat of cancer and the potential to die young, Phoebe Snetsinger began a life of traveling for birds. In the process she made numerous friends in over 60 countries. I estimate she did ten to a dozen trips a year and spent about U.S.$50 000/ year in today's currency. Overall, she must have made hundreds of trips.

A neat bonus is the group of 29 black-and-white and 16 colour illustrations by Douglas Pratt. They portray the key milestone birds of Phoebe's impressive odyssey. They are well done and make a nice counterpoint to the text.

This is certainly a book for all birders. However, it is not simply a long list of birds seen, but a rampaging account of Phoebe's obsession. This lady survived

gang rape, robbery, accidents, family crises, mechanical breakdowns, bad service and bad food against a background threat of cancer. Nothing seemed to slow her down. It is a tale of the fortitude of the human spirit. Indeed, I think a revision of this with the birding-related material severely edited (after all, which non-birder will realize the importance of a Red-shouldered Vanga – a small, House Sparrow-sized grey, black-and-white bird with bright chestnut shoulders – and its ilk?) would make it ideal for one of those inspirational stories we find in Reader's Digest. Having finally seen a Red-shouldered Vanga, Phoebe was asleep in the tour bus when the bus crashed and she was killed. So she did not die of cancer, but binoculars in hand, on a birding trip. I never did meet this lady – pity!

ROY JOHN

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NEW TITLES

Zoology

†**The American Bison**. By D. Lott. 2004. University of California Press. 229 pages, $40 U.S. Paper.

† **Annotated Bibliography of the Quaternary Vertebrates of Northern North America.** 2003. Edited by C. R. Harrington. University of Toronto Press. xxii plus 539 pages, not illustrated. $150 Cloth, $75. Paper.

Annotated Checklist of the Birds of Chile. By Manuel Marín. Lynx Edicions, Barcelona, Spain. US$15.75.

Behavior and Ecology of Pacific Salmon and Trout. By T. Quinn. UBC Press, 2029 West Mall, Vancouver, British Columbia V6T 1Z2 Canada. 400 pages, $85.

Big Cat Diary: Leopard. By Jonathan Scott and Angela Scott. Harper Collins. 128 pages, $42.

* **The Bird Almanac**. By D. Bird. 2004. Key Porter Books, 70 The Esplanade, Toronto, Ontario, Canada. xvii + 460 pages, not illustrated, $24.95. Paper.

Birding in Venezuela. By Mary Lou Goodwin. Lynx Edicions, Barcelona, Spain. US$ 5.60.

Birds of South Asia: The Ripley Guide. Volumes I and II. By Pamela C. Rasmussen and John C. Anderton. Lynx Edicions, Barcelona, Spain. US$95.

Bowerbirds – Ptilonorhychidae. Edited by Clifford Frith. Oxford University Press, 70 Wynford Drive, Don Mills, Ontario M3C 1J9 Canada. 416 pages. $209 Cloth.

† **British Columbia – A Natural History**. By R. and S. Cannings. 2004. Greystone Books, Douglas and McIntyre, Vancouver, British Columbia, Canada. ix + 341 pages. $39.95 Paper.

† **The Buffalo Wolf**. 2003. By Lu Carbyn. Smithsonian books, Washington, D.C., USA. 248 pages. Paper.

Curassows and Related Birds. By Jean Delacour and Dean Amadon. Update Chapter by Josep del Hoyo and Anna Motis. Illustrated by Albert Earl Gilbert. Lynx Edicions, Barcelona, Spain. US$75.

† **Ecology and Conservation of Birds in the Salton Sink: an Endangered Ecosystem.** By W. David Shuford and Kathy C. Molina. 2004. Studies in Avian Biology Number 27. Cooper Ornithological Society.

* **A Field Guide to the Bird's Nests and Eggs of Alaska Coastal Tundra**. By T. Bowman. 2004. Alaska Sea Grant College Program.

† **A Guide to Hawk Watching in NA**. By D. Heintzleman. 2004. The Globe Pequot Press.

† **Mammal Tracks and Signs.** By Mark Elbroch. 2004. Stackpole Books.

† **Key Marine Habitat Sites for Migratory Birds in Nunavut and the Northwest Territories.** 2004. By M. Mallory and A. Fontaine. 2004. Canadian Wildlife Service, Ottawa, Ontario K1A 0H3. Paper.

† **Orca – Visions of the Killer Whale**. By P. Knudtson. 2004. Greystone Books, Vancouver, British Columbia. xvii +110 pages. $19.95. Paper.

Readers Digest Birds of Canada. Edited by R. Greenberg et al. 2004. Dorling Kindersly India Ltd., c/o Tourmaline Editions, 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7.

Reptiles and Amphibians of the Amazon: An Ecotourist's Guide. By R. D. Bartlett and P. Bartlett Florida University Presses, USA. 291 pages. $57 Canadian. Paper.

Wild Down Under: The Natural History of Australasia. By Neil Nightingale, Jeni Clevers, Neil Pearson and Mary Summerill. BBC Video. 240 pages, $50 Canadian. Cloth.

Botany

The Wild Flowers of Britain and Ireland – The Complete Guide to the British and Irish Flora. By Marjorie Blamey, Richard Fitter and Alastair Fitter. A & C Black. 512 pages, $42 Canadian. Paper.

Environment

***Bull's Eye – Unraveling the medical mystery of Lyme Disease**. By Jonathon Edlow. 2004. Yale University Press, Box 209040, New Haven, Connecticut.

† **Canoeing, Kayaking & Hiking Temagami**. By Hap Wilson. 2004. The Boston Mills Press (Firefly Books), 132 Main Street, Erin, Ontario. 112 pages, $24.95.

† **Chicken Soup for the Fisherman's Soul**. By J. Canfield, M. Hansen, K. & Dahlynn McKowen. 2004. Health Communications Inc. Paper.

Dictionary of Ecology. By Michael Allaby. 2004. Oxford University Press, 70 Wynford Drive, Don Mills, Ontario M3C 1J9. 448 pages, $29.95.

† **The Importance of Species**. Edited by P. Karliva and S. Levin. 2004. Princeton University Press, 41 William Street, Princeton, New Jersey. xvi + 427 pages, not illustrated, Paper.

† **Lewis and Clarke on the Great Plains.** By Paul Johnsgard. 2003. University of Nebraska Press. xiv + 143 pages, $14.95 U.S.

† **Missinaibi.** By Hap Wilson. 2004. The Boston Mills Press (Firefly Books), 132 Main Street, Erin, Ontario. 134 pages, $24.95.

† **A place between the tides: A naturalist's reflections on the salt marsh**. By Harry Thurston. 2004. Greystone Books. Paper. $22.95 CAAD, $15.00 U.S.

† **Politics of the Wild – Canada & Endangered Species.** Edited by K. Beazley and R. Boardman. 2004. Oxford University Press, 70 Wynford Drive, Don Mills, Ontario. x + 254 pages, not illustrated, $29.95 Paper.

Population Ecology: First Principles. By John H. Vandermeer and Deborah E. Goldberg. Princeton UP, USA. 280 pages, $123 Cdn, Cloth.

A Primer of Ecological Genetics. By J. Conner and D. Hartt. 2004. Sinauer Associates, Box 407, Sunderland, Massachusetts. 207 pages, $34.95 U.S., Paper.

* **Resource and Environmental Management in Canada**. Edited by B. Mitchell. 2004. Oxford University Press, 70 Wynford Drive, Don Mills, Ontario. x + 600 pages, $29.95 Paper.

† **Rivers of the Upper Ottawa Valley**. By Hap Wilson. 2004. The Boston Mills Press (Firefly Books), 132 Main Street, Erin, Ontario. 112 pages, $24.95.

† **The Selbourne Pioneer**. By T. Dodswell. 2004. Ashgate Publising Company, Suite 420, 101 Cherry St., Burlington, Vermont, USA. xvii + 238 pages, not illustrated. Paper.

† **Shaped by the West Wind – Nature and History in Georgian Bay**. By C. Campbell. 2004. UBC Press, 2029 West Mall, Vancouver, British Columbia, V6T 1Z2 Canada. 256 pages, $85 Cdn.

The Smithsonian Atlas of the Amazon. By Michael Goulding, Ronaldo Barthem and Efrem Ferreira. Smithsonian Books, Washington, D.C., USA. 255 pages, $75 Cdn. Cloth.

† **Teaching in Eden**. 2003. By J. Janovy Jr. Routledge, 29 West 35th St., New York, New York 10001 USA. 187 pages, not illustrated, $22.95 U.S., Paper.

† **Wilderness Rivers of Manitoba**. By Hap Wilson and S. Aykroyd. 2004. The Boston Mills Press (Firefly Books), 132 Main Street, Erin, Ontario, Canada. 112 pages, $24.95.

† Available
*Assigned

News and Comment

Update on Quebec Amphibian and Reptile Atlas Project: Rana-Saura 6(2)

The newsletter *Rana-Saura* resumes with Volume 6, Number 2 issued for April 2004. The previous issue was published in March 2000. Due to translation expense no English version is currently available of the new issue (of 383 participants, only 23 are anglophones). Contents are: Et ça continue! – Atlas des amphibiens et des reptiles du Québec – Suivi des populations d'amphibiens du Québec – La présence de la Rainette faux-grillon boreale [*Pseudarcris maculata*] enfin confirmée [Jean-François Desroches] – Un nouvelle reptile pour Québec! [Jean-François Desroches] – Le tout nouveau guide d'identification des amphibiens et des reptiles du Québec!

Rana-Saura is edited by David Rodrigue, for the Atlas of amphibians and reptiles of Quebec (continuing in 2004 in its 17th year; since 2002 the entries have increased from 22 000 to nearly 45 000) and the Survey of populations of amphibians of Quebec (in 2004 there will be 45 participants conducting 42 road surveys). These projects are coordinated by the Ecomusuem of the St. Lawrence Valley Natural History Society and financially aided by La Sociéte de la Faune et des Parcs du Québec.

It is distributed by St. Lawrence Valley Natural History Society, 21-125 chemin Sainte-Marie, Sainte-Anne-de-Bellevue, Quebec H9X 3Y7 Canada. Phone (514) 457-9449, extension 105: Fax (514) 457-0769; e-mail: ecomus@total.net.

Froglog: Newsletter of the Declining Amphibian Populations Task Force (62)

Number 62, April 2004. Contents: Southern African Frog Atlas Project completed! (Marius Burger and J. A. Harrison) – Mark Twain's frog not croaked after all! (Robert Stack) – Decline of the Kihansi Spray Toad, *Nectophrynoides aspergini*s from the Udzungwa Mountains, Tanzania (Che Weldon & Louis H. du Preez) – The Amphibian Fauna of Nagaland, India: Species and Habitats (Meren Ao & Sabitry Bordoloi) – Seed Grant News – Froglog Shorts.

Froglog is the bi-monthly newsletter of the Declining Amphibian Populations Task Force of The World Conservation Union (IUCN)/Species Survival Commission (SSC) and is supported by The Open University, The World Congress of Herpetology, and Arizona State University. The newsletter is edited by John W. Wilkinson, Department of Biological Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, United Kingdom; e-mail: daptf@open.ac.uk. Funding for *Froglog* is underwritten by the Detroit Zoological Institute, P. O. Box 39, Royal Oak, Michigan 48068-0039, USA. Publication of issue 62 was also supported by Peace Frogs www.peacefrogs.com and by RANA and the U.S. National Science Foundation grant DEB-0130273.

Amphipacifica: Journal of Aquatic Systematic Biology 3(4)

Volume 3, Number 4, dated 30 March 2004, is 113 pages and contains the talitroidean amphipod family Najnidae in the North Pacific region: systematics and distributional ecology (E. L. Bousfield and Pierre Marcoux) and The amphipod family Pleustidae (mainly subfamilies Mesopleustinae. Neopleustinae, and Stenopleustinae) from the Pacific coast of North America: systematics and distributional ecology (E. A. Hendrycks and E. L. Bousfield).

Amphipacifica (ISSN 1189-9905) is published quarterly by Amphipacifica Research Publications, Edward L. Bousfield, Managing Editor, 1710-1275 Richmond Road, Ottawa, Ontario K2B 8E3 Canada. Annual subscription rates are $40.00 US or $50.00 Canadian funds. Back numbers are available at $10 each.

Marine Turtle Newsletter (104)

April 2004. 36 pages: ARTICLES: Nesting of Hawksbill Turtles in Paraiba-Brazil: Avoiding Light Pollution Effects – Stranding of Small Juvenile Leatherback Turtle in Western Australia – Post-nesting Movements of Green Turtles Tagged in the Turtle Islands, Tawi-Tawi, Philippines – Notes from Preliminary Market Surveys in Morocco – NOTES: Recoveries of Two Post-hatching Loggerhead Turtles in the Northern Adriatic Sea – Green Turtle Nesting on the Gulf of Oman Coastline of the Islamic Republic of Iran – Confirmed Nesting of the Loggerhead Turtle in Corsica – Marine Turtles in Iran: Results from 2002 – Sightings of the Leatherback Turtle off the Southern Coast of Rio de Janeiro, Brazil – MEETING REPORTS – IUCN/SSC MTSG News – BOOK REVIEWS – ANNOUNCEMENTS NEWS & LEGAL BRIEFS – RECENT PUBLICATIONS.

The Marine Turtle Newsletter is edited by Brendan J. Godley and Annette C. Broderick, Marine Turtle Research Group, School of Biological Sciences, University of Exeter, Exeter EX4 4PS United Kingdom; e-mail MTN@seaturtle.org; Fax +44 1392 263700. Subscriptions and donations towards the production of both the MTN and its Spanish edition NTM [Noticiero de Tortugas Marinas] should be made online at www.seaturtle.org/mtn or c/o SEATURTLE.ORG 11400 Classical Lane, Silver Spring, Maryland 20901 USA.

Erratum 118(1): 80

Sloan, N. A., and **P. M. Garier.** 2004. Introduced marine species in the Haida Gwaii (Queen Charlotte Islands) Region, British Columbia. Canadian Field-Naturalist 118(1): 77-84.

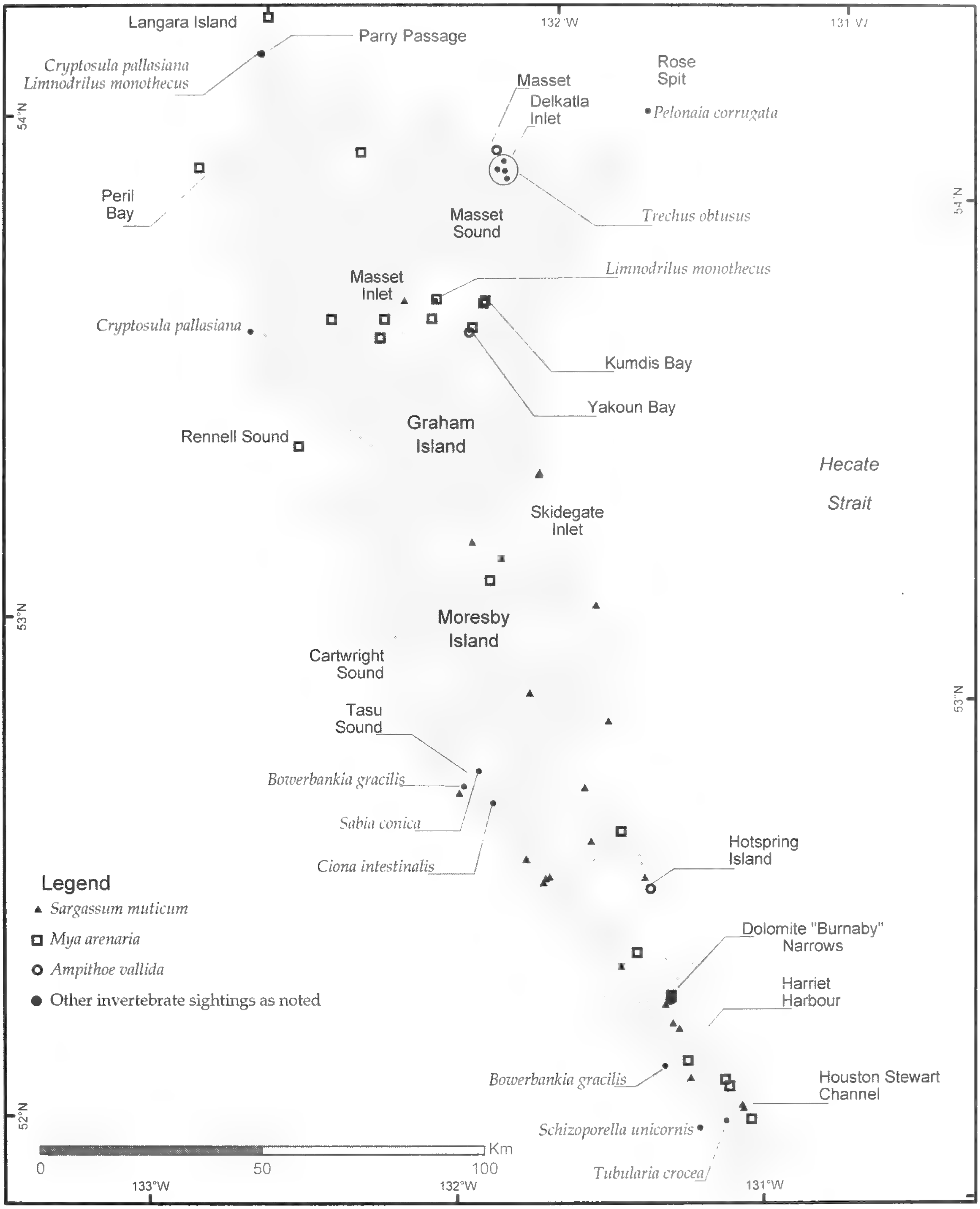

FIGURE 1. Map of Haida Gwaii showing locations mentioned in the text and collection sites of introduced marine plant and invertebrate species, based on data from Sloan and Bartier (2000) and Sloan et al. (2001).

Editor's Report for Volume 117 (2003)

Mailing dates for issues in volume 117 were: (1) 30 September 2003, (2) 23 March 2004, (3) 12 July 2004, (4) 16 September 2004.

A summary of membership and subscriber totals 2003 is given in Table 1. The number of articles and notes in volume 117 is summarized in Table 2 by topic; totals for Book Reviews and New Titles are given in Table 3, and the distribution of content by page totals per issue in Table 4. Council continued contribution of 40% of membership dues for publication. All of subscriptions (both individual and institutional) also go toward publication. As well, the Council allocated 80% of the annual interest from the Manning Fund and other capital funds to *The Canadian Field-Naturalist*. The Manning fund portion is specifically to offset the publication cost of northern papers where author and institutional contributions were insufficient to cover page charges.

Emil Holst arranged setting and printing at St. Joseph Print Group, Ottawa, for 117(1), with special thanks due Cameron Fraser and Willy Silfwerbrand, and at Gilmore Printers, Ottawa, for 117 (2,3,4) with special thanks to Wendy Cotie and Ally Reckzin. Leslie Cody prepared the Index, Elizabeth Morton read the galleys. Bill Cody as Business Manager handled all reprint requests and charges and oversaw and proofed the compilation of the Index. Wilson Eedy continued as Book-Review Editor until his death in June, and Roy John replaced him in August 2004.

Manuscripts (excluding book reviews, notices, and reports) submitted to *The Canadian Field-Naturalist* totalled 84 in 2003, down 16 from 100 in 2002. The following reviewed for papers submitted in 2003: *Associate Editors*: (number of manuscripts reviewed in parentheses): R. Anderson, Canadian Museum of Nature, Ottawa (5): C. D. Bird, Erskine, Alberta (14); B. W. Coad, Canadian Museum of Nature, Ottawa (10); R. R. Campbell, St. Albert, Ontario (6); P. M. Catling, Agriculture and Agri-food Canada, Ottawa (11); A. J. Erskine, CWS, Sackville, New Brunswick (13); D. F. McAlpine, New Brunswick Museum, Saint John, N.B. (8); D. W. Nagorsen, Victoria, British Columbia (11); W. O. Pruitt, Jr., University of Manitoba, Winnipeg (21); *Others*: (one review each except as marked): P. Achuff, Waterton National Park, Alberta; Y. Alarie, Laurentian University, Sudbury, Ontario; N. Alfonso, Canadian Museum of Nature, Ottawa, Ontario; J. F. Bain, University of Lethbridge, Alberta; R. Bird, Cascadia Research, Olympia, Washington; K. Bellamy, OMNR, Peterborough; J. R. Bider, Ecomuseum, Ste-Anne-de-Bellevue, Quebec (3); E. L. Bousfield, Ottawa, Ontario; J. P. Bogart, University of Guelph, Ontario; I. Brodo, Canadian Museum of Nature, Ottawa, Ontario (2); R. J. Brooks, University of Guelph, Ontario; J. Calambokidis, Cascadia Research, Olympia, Washington; S. E. Campana, Bedford Institute of Oceanography,

TABLE 2. Number of articles and notes published in *The Canadian Field-Naturalist* Volume 117 (2003) by major field of study.

Subject	Articles	Notes	Total
Mammals	19 *	14	33
Birds	17 *	6	23
Amphibians + reptiles	4	1	5
Fish	3	2	5
Invertebrates	6	1	6
Plants**	16	3	19
Tributes	2	0	2
Totals	67	27	93

*one article counted twice, one in each group: **includes one feature article.

TABLE 1. The 2003 circulation of The Canadian Field-Naturalist (2002 in parenthesis). Totals compiled by W. J. Cody. Forty percent of membership dues and 100% of subscriptions go to publication of *The Canadian Field-Naturalist*. Members vote on Club affairs, subscribers and institutions do not.

	Canada		USA		Other		Totals	
Memberships								
Family & individual	795	(911)	36	(32)	7	(8)	838	(951)
Subscriptions								
Individuals	163	(164)	60	(65)	6	(5)	229	(234)
Institutions	157	(171)	241	(252)	30	(32)	428	(455)
Totals	1005	(1246)	337	(349)	43	(45)	1495	(1640)

Note: 22 countries are included under "Other" (outside Canada and United States): Austria, Belgium, Brazil, Denmark (2), United Kingdom (9: including 1 to Scotland), Finland (2), France (3: including 1 to St. Pierre & Miquelon), Germany (2), Iceland, Ireland, Japan, Mexico, Netherlands (3), New Zealand, Norway (4), Poland, Russia, South Africa, Spain (3), Sweden (2), Switzerland (2), Trinidad and Tobago.

TABLE 3. Number of reviews and new titles published in Book Review section of *The Canadian Field-Naturalist* Volume 117 by topic.

	Reviews	New Titles
Zoology	40	30
Botany	11	23
Environment	22	41
Miscellaneous	12	18
Young Naturalists	0	18
Totals	85	130

TABLE 4. Number of pages per section published in *The Canadian Field-Naturalist* Volume 117 (2003) by issue.

	(1)	(2)	(3)	(4)	Total
Articles	127	135	109	119	490
Notes	12	16	15	17	60
Tributes	11	0	16	0	27
Book Reviews*	13	25	26	18	82
CFN/OFNC Reports	**	0	2	8	212
News and Comment	3	2	1	2	8
Index	0	0	0	30	30
Advice to Contributors	0	0	1	0	1
Totals	166	180	176	188	710

*Total pages for book review section include both reviews and new titles listings.
**Includes CFN Editors reports (issue 2), OFNC Annual Business Meeting (3) and OFNC Awards (4).

Dartmouth, Nova Scotia; L. Carbyn, Canadian Wildlife Service, Edmonton, Alberta (4); A. Ceska, Victoria, British Columbia; A. H. Clarke, Jr., Portland, Texas; W. J. Cody, Agriculture and Agri-food Canada, Ottawa; V. Craig, EcoLogic Research, Gabriola Island, British Columbia; M. Crete, Ministere de l'Environnement et de la Faune, Quebec; E. J. Crossman, Royal Ontario Museum, Toronto, Ontario; S. J. Darbyshire, Agriculture and Agri-food Canada, Ottawa; R. Day, Canadian Museum of Nature, Ottawa; C. Ely, U. S. Fish and Wildlife Service, Anchorage, Alaska; M. Engstrom, Royal Ontario Museum, Toronto; B. Erickson, Salon. Ohio; M. Fairbarns, Conservation Data Centre, B. C. Government, Victoria; M. Gosselin, Canadian Museum of Nature, Ottawa; T. Goward, Clearwater, British Columbia; W. A. Fuller, Athabasca University, Alberta; D. Galbraith, Royal Botanical Gardens, Hamilton, Ontario; Marco Festa-Bianchet, University of Sherbrooke, Quebec; P. T. Gregory, University of Victoria, British Columbia (2); D. Gummer, Provincial Museum of Alberta, Edmonton (2); E. Haber, National Botanical Services, Ottawa; F. Harrington, Mt. St. Vincent University, Halifax, Nova Scotia; R. Harrington, Canadian Museum of Nature, Ottawa; D. Henry. Parks Canada, Haines Junction, Yukon Territory; S. Herrero, University of Calgary, Alberta; G. V. Hilderbrand, Alaska Department of Fish and Game, Anchorage; R. P. Hodge, Gig Harbor, Washington; C. S. Houston, Saskatoon, Saskatchewan (2); E. Holm, Royal Ontario Museum, Toronto; G. Jarrell, University of Alaska Museum, Fairbanks, Alaska; D. Johnson, Canadian Forest Service, Edmonton, Alberta; N. Jotham, NRJ Technical Services, Trade & Animal Welfare, Ottawa; R. B. King, Northern Illinois University, DeKalb, Illinois; J. L. Koprowski, Wildlife and Fisheries Resources, University of Arizona, Tucson; S. Lariviere, Delta Waterfowl Foundation, Portage La Prairie, Manitoba; D. Larson, Memorial University of Newfoundland, St. John's; L. E. Licht, York University, North York, Ontario; J. Lien, Memorial University of Newfoundland, St. John's; S. Lindgren, University of Northern British Columbia, Prince George; G. L. Mackie, University of Guelph, Ontario; F. F. Mallory, Laurentian University, Sudbury, Ontario; A. Martel, Canadian Museum of Nature, Ottawa; John Maunder, Newfoundland Museum, St. John's, Newfoundland; M. K. McNicholl, Burnaby, British Columbia; G. R. Michener, University of Lethbridge, Alberta; G. Mulligan, Agriculture and Agri-food Canada, Ottawa; E. Nol, Trent University, Peterbourgh; P. Paquet, Meacham, Saskatchewan; K. Prior, Canadian Wildlife Service, Ottawa; G. Proulx, Alpha Research & Management Ltd., Sherwood Park, Alberta; C. Renaud, Canadian Museum of Nature, Ottawa, Ontario; B. Riddell, Pacific Biological Station, Nainimo, British Columbia; R. A. Ring, University of Victoria, British Columbia; James Schaefer, Trent University. Peterborough, Ontario; W. B. Schofield, University of British Columbia, Vancouver; F. W. Schueler, Oxford Station, Ontario; B. Slough, Whitehorse, Yukon Territory; I. Stirling, Canadian Wildlife Service, Edmonton, Alberta (2); J. Straley, University of Alaska Southeast, Sitka, Alaska; D. Strickland, Dwight, Ontario; E. S. Telfer, Edmonton, Alberta; I. Thompson, Canadian Forest Service, Sault Ste. Marie, Ontario; C. Traynor, Ottawa, Ontario; N. Vachon, Socièete de la faune et des parcs du Québec, Longueuil; P. Weigl, Wake Forest University, Winston-Salem, North Carolina; G. Wobeser, Western College Veterinary Medicine, University of Saskatchewan, Saskatoon; J. N. Womble, University of Alaska-Fairbanks, Juneau, Alaska; P. M. Youngman, Ottawa, Ontario (2).

I am also indebted to the President of the Ottawa Field-Naturalists' Club Gary McNulty and the Club Council for continuing support of the journal; Chairman Ron Bedford and the Publications Committee of the OFNC for editorial encouragement and support, to the Canadian Museum of Nature for access to its library and the facilities at the Natural Heritage Building, 1740 Pink Road, Aylmer, Quebec, and to Joyce for everything else.

FRANCIS R. COOK
Editor

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Please submit, **to the Editor,** in either English or French, **three** complete manuscripts **written in the journal style.** The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Print the manuscript on standard-size paper, **doublespace throughout,** leave generous margins to allow for copy marking, and **number each page.** For Articles and Notes provide a citation bibliographic strip, an abstract and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in the text or in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Check recent issues (particularly Literature Cited) for journal format. Either "British" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations

Photographs should have a glossy finish and show sharp contrasts. Electronic versions should be high resolution. Photographic reproduction of line drawings, **no larger than a standard page,** are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the journal.

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Limited journal funds are available to help offset publication charges to authors with minimal financial resources. Requests for financial assistance should be made to the Business Manager when the manuscript is accepted.

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FRANCIS R. COOK, Editor
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Notes

Book Reviews

News and Comment

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Articles

(continued on inside back cover)

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Cover: International zone on rugged rock headland of the Queen Charlotte Islands, British Columbia, each dominant species creating a distinct zone. The white lichen is mainly *Coccotrema maritimum* and the black one is almost entirely *Verru cana maura*. Below the *Verru cana* is a zone bare of both lichens and marine algae, and, still lower, the algae take over. Figure 64 (page 77). *Lichens of North America*. By I. M. Brodo, S. D. Sharnoff, and S. Sharnoff. 2001. Yale University Press, New Haven, Connecticutt. See article by Brodo and Sloan on lichen zonatum pages 405-424.

The Canadian Field-Naturalist

Volume 118, Number 3 July–September 2004

Population Dynamics of Deer Mice, *Peromyscus maniculatus,* and Yellow-pine Chipmunks, *Tamias amoenus,* in Old Field and Orchard Habitats

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Sullivan, Thomas P., Druscilla S. Sullivan, and Eugene J. Hogue. 2004. Population dynamics of Deer Mice, *Peromyscus maniculatus,* and Yellow-pine Chipmunks, *Tamias amoenus,* in old field and orchard habitats. Canadian Field-Naturalist 118(3): 299-308.

There are often several rodent species included in the small mammal communities in orchard agro-ecosystems. This study was designed to test the hypothesis that the population levels of Deer Mice (*Peromyscus maniculatus*) and Yellow-pine Chipmunks (*Tamias amoenus*) would be enhanced in old field compared with orchard habitats. Rodent populations were intensively live-trapped in replicate old field and orchard sites over a four-year period at Summerland, British Columbia, Canada. Deer Mouse populations were, on average, significantly higher (2.5 – 3.4 times) in the old field than orchard sites in summer and winter periods. Mean numbers/ha of Deer Mice ranged from 12.1 to 60.4 in old field sites and from 3.3 to 19.9 in orchard sites. Breeding seasons in orchards were significantly longer than those in old field sites, in terms of proportion of reproductive male Deer Mice. Recruitment of new animals and early juvenile survival of Deer Mice were similar in orchard and old field sites. Populations of Yellow-pine Chipmunks ranged in mean abundance/ha from 5.6 – 19.0 in old field sites and from 1.9 – 17.5 on one orchard site, with no difference in mean abundance in 2 of 4 years of the study. Recruitment and mean survival of Yellow-pine Chipmunks also followed this pattern. This study is the first detailed comparison of the population dynamics of these rodent species in old field and orchard habitats. These species should be able to maintain their population levels and help contribute to a diversity of small mammals in this agrarian landscape.

Key Words: Deer Mouse, *Peromyscus maniculatus*, Yellow-pine Chipmunk, *Tamias amoenus*, abundance, demography, old field, orchard, population dynamics, recruitment, reproduction, British Columbia.

Voles of the genus *Microtus* are often the major rodent species in perennial grasslands and agro-ecosystems. In addition to grasses and herbs, these microtines feed on vascular tissues of tree and other crop plants primarily during winter months (Byers 1985; Lewis and O'Brien 1990). Other major rodent species include the Deer Mouse (*Peromyscus maniculatus*) and Yellow-pine Chipmunk (*Tamias amoenus*), which may occur in tree fruit orchards and adjacent habitats in the inland regions of the Pacific Northwest of North America. Neither of these associated species is known to damage orchard trees by their feeding activity as they are granivorous or insectivorous in their feeding habits (Baker 1968; Webster and Jones 1982; Sutton 1992).

Deer Mice or White-footed Mice (*P. leucopus*) commonly occur with *Microtus* in old fields and other perennial grassland habitats (Tamarin 1977; Krebs 1979; Dueser et al. 1981; Sullivan and Krebs 1981; Schweiger et al. 2000; Manson et al. 2001; Pearson et al. 2001) and in orchard agro-ecosystems (Sullivan et al. 1998). Few studies of voles in orchards have reported on the population dynamics of other species in the small mammal community. Sullivan et al. (1998) discussed the population responses of all species to vegetation management in apple (*Malus domestica*) orchards and Sullivan et al. (2000) reported changes in species diversity of these communities in orchards and old fields.

Orchard habitats usually have frequent mowing and vegetation management treatments during summer months, and hence conditions for small mammals are more changeable than in old fields. Thus, this study was designed to test the hypothesis that the population dynamics of Deer Mice and Yellow-pine Chipmunks would be enhanced in old field compared with orchard habitats. To evaluate this hypothesis, we provide a detailed analysis of the population dynamics of these species in the two habitats.

Materials and Methods

Study area and experimental design

This study was conducted at the Pacific Agri-Food Research Centre in the Okanagan Valley, Summerland, British Columbia, Canada. The experimental design consisted of two replicate "old field" and two replicate orchard habitats. The old field habitats were abandoned (≥25 years) hay fields composed of Crested Wheatgrass (*Agropyron cristatum*), Quack Grass (*Agropyron repens*), Downy Brome (*Bromus tectorum*), Diffuse Knapweed (*Centaurea diffusa*), with some minor herbaceous species such as Yellow Salsify (*Tragopogon dubius*), Great Mullein (*Verbascum thapsus*), American Vetch (*Vicia americana*), Prickly Lettuce (*Lactuca serriola*), and Tall Tumble-mustard (*Sisymbrium altissimum*). These old field sites were each 2 to 3 ha in area within a mosaic of sagebrush (*Artemisia tridentata*), Ponderosa Pine (*Pinus ponderosa*) forest, and orchard habitats. These old fields had resident populations of Deer Mice and Yellow-pine Chipmunks. Other species included the Montane Vole (*Microtus montanus*), Great Basin Pocket Mouse (*Perognathus parvus*), Western Harvest Mouse (*Reithrodontomys megalotis*), and a few Long-tailed Voles (*M. longicaudus*).

The orchards were: (A) a five-year-old apple orchard unit, and (B) a 10-year-old apple orchard combined with a 15-year-old pear (*Pyrus* sp.) orchard as one unit. Both 1.2-ha orchards were located within a 90-ha mosaic of tree fruits and vineyards. Thus, our experimental design had two true replicates of old field sites and two replicates of orchard sites. Each pair of old field and orchard sites was spatially segregated to enhance statistical independence (Hurlbert 1984). A third replicate pair would have strengthened the study but was not possible within the operational setting of the Research Centre.

Common grass species on the orchard sites included Orchard Grass (*Dactylis glomerata*), Quack Grass, bluegrass (*Poa* spp.), Smooth Brome (*Bromus inermis*), and Crested Wheatgrass. These orchards were mowed five or six times each summer. Rodenticides were applied 3-4 times each winter in poison-bait feeder stations (Radvanyi 1974) for voles (Mouse Bait II® – zinc phosphide and Ramik Brown® – diphacinone). Rodenticides were not present in the old field sites.

Deer Mouse and Yellow-pine Chipmunk populations

All animals were live-trapped on 1-ha grids with 49 (7 × 7) trap stations located at 14.3-m intervals with one or two Longworth live-traps at each station. One of the old-field grids was an irregular shaped rectangle of 1 ha with the same 49 stations. The four grids (2 orchard and 2 old field) were live-trapped at 3-week (spring, summer, and fall) and at 4- to 6-week (winter) intervals from June 1982 to April 1986.

Traps were baited with whole oats, peanut butter, and carrot; coarse brown cotton was supplied as bedding. Traps were set on day 1, checked on the morning and afternoon of day 2 and morning of day 3, and then locked open between trapping periods. All animals captured were ear-tagged with serially numbered tags, breeding condition noted, weighed on Pesola spring balances, and point of capture recorded. The duration of the breeding season was noted by palpation of male testes and the condition of mammaries of the females (Krebs et al. 1969). A pregnancy was considered successful if a female was lactating during the period following the estimated time of birth of a litter. Animals were released on the grids immediately after processing.

Seasons were defined as summer (April to September) and winter (October to March) periods. Thus, there were four summer and four winter periods from 1982 to 1986. We used mass at sexual maturity to infer age classes of animals. Body mass was used as an index of age. The percentage of sexually mature animals was used to determine the mass limitations for juveniles and adults assuming that juveniles were seldom, if ever, sexually mature, and that at least 50% of the adults were sexually mature in their lowest mass class. Deer Mice (juvenile = 1 – 20 g, adult ≥ 21 g) and Yellow-pine Chipmunks (juvenile = 1 – 44 g, adult ≥ 45 g) were classified as juvenile or adult by body mass. Juveniles were considered to be young animals recruited during the study. Recruits were defined as new animals that entered the population through reproduction and immigration. All handling of animals was in accordance with the principles of the Animal Care Committee, University of British Columbia.

Demographic parameters

Population densities were estimated by the Jolly-Seber model for reasons indicated by Jolly and Dickson (1983). The Jolly-Seber (J-S) model provides the best estimates of population size for mark and recapture data when trappability values are generally < 70% (Hilborn et al. 1976). However, when population size falls very low and no marked animals are recaptured, the J-S estimate becomes unreliable and impossible to calculate (Krebs et al. 1986). For these sample weeks, a minimum number of animals known to be alive (MNA) (Krebs 1966) value was substituted for a biologically unreasonable J-S estimate.

Measurements of recruitment, number of lactating females, and early juvenile survival were derived from the sample of animals captured in each trapping session and then summed for summer periods. Early juvenile survival is an index relating recruitment of young into the trappable population to the number of lactating females (Krebs 1966). A modified version of this index is number of juvenile animals at week t divided by the number of lactating females caught in week $t - 3$. Mean survival rates (28-day) for summer and winter periods were estimated from the Jolly-Seber model. Mean body mass of combined males and females

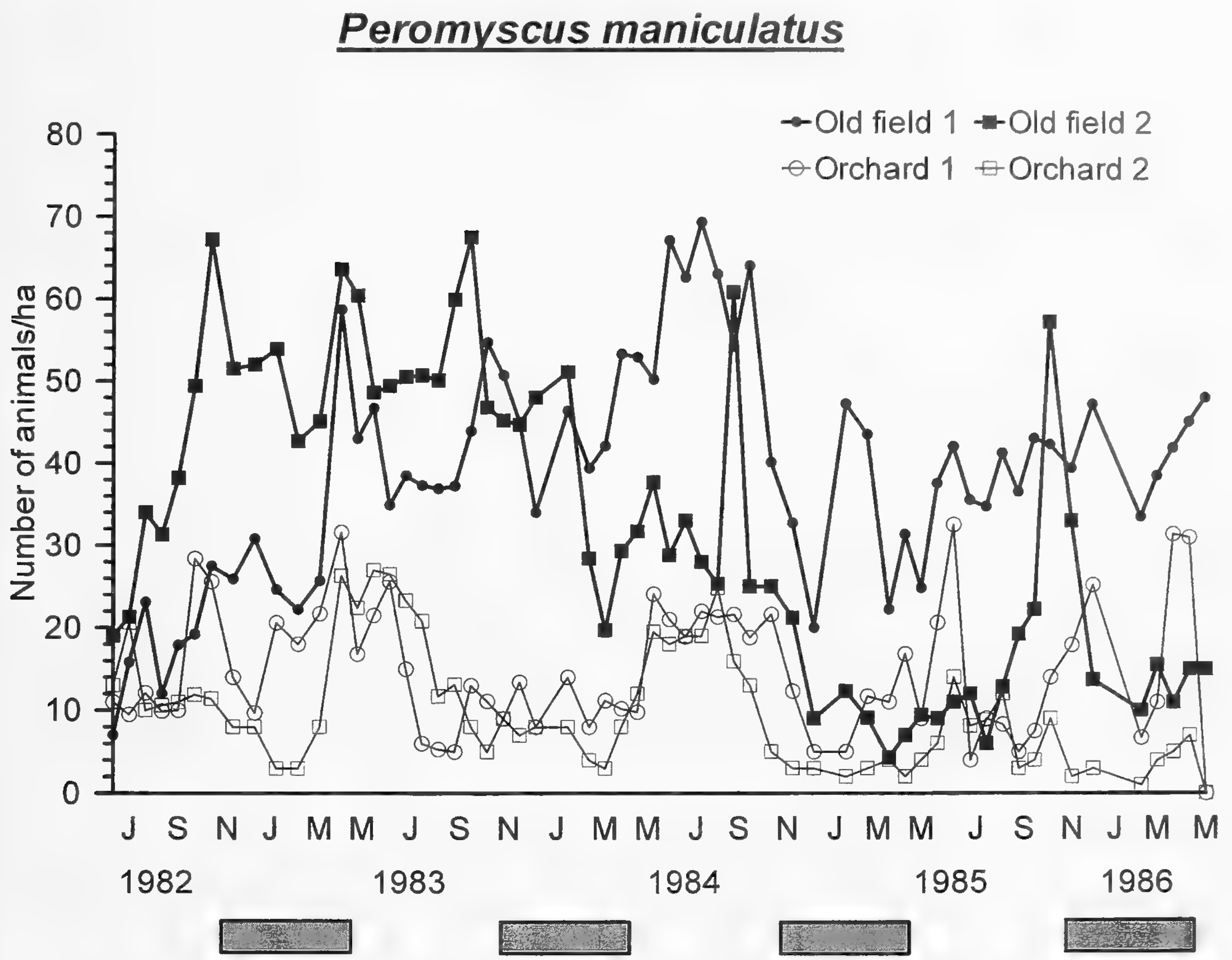

FIGURE 1. Population densities (Jolly-Seber) per ha of Deer Mice in replicate old field and orchard sites during the study. Shaded bars indicate winter periods. Months of year are represented by J = July; S = September; N = November; J January; M = March; M = May.

was used as an index of condition within populations of Deer Mice and Yellow-pine Chipmunks during summer and winter periods.

Statistical analysis

Mean trappability, mean abundance, mean number of recruits, mean Jolly-Seber survival rates, and mean body mass were evaluated by 95% confidence intervals (CI) for Deer Mice and Yellow-pine Chipmunks in old field and orchard sites during summer and winter periods, as per the recommendations of Gerard et al. (1998) and Johnson (1999). Proportion of adult males and adult females breeding was analyzed by a Chi-square 2×2 contingency table (Zar 1984) for each of the four summer periods. These datasets of proportion of animals breeding often include animals captured more than once, and hence they are not completely independent. Thus, the Chi-square analyses provide only an indication of the degree of difference between datasets. In all analyses, the level of significance was $P = 0.05$.

Results

Deer Mouse populations

Totals of 751 and 459 individual Deer Mice were captured on the two old field and two orchard sites, respectively. Mean J-S trappability estimates for Deer Mice ranged from 62.6% to 73.8% in summer and from 46.6% to 76.6% in winter in the old field sites. These estimates in the orchard sites ranged from 48.0% to 81.7% in summer and from 39.0% to 80.8% in winter.

Deer Mouse populations were, on average, generally higher (2.5 – 3.4 times) in the old field than orchard sites in summer and winter periods (Figure 1). There were some exceptions to this pattern in summers 1982 and 1985 and winter 1985-1986 when mean abundance of Deer Mice was similar, at least in one old field—orchard site comparison (Table 1). Numbers of Deer Mice reached annual autumn peaks ranging from 30.8 to 69.3 animals/ha in the old field-1 site and from 57.2 to 67.5 animals/ha in the old field-2 site.

TABLE 1. Mean abundance per ha ± 95% confidence intervals for Deer Mice during summer and winter periods in replicate old field and orchard sites. Sample size (n = number of trapping periods) in parentheses.

Period		Old field 1	Old field 2	Orchard 1	Orchard 2
Summer 1982	χ^2	17.5	37.2	15.2	12.6
(7)	95% CI	11.2 – 23.8	21.7 – 52.7	7.7 – 22.7	9.3 – 16.0
Winter 1982-83	χ^2	25.8	49.0	16.8	6.0
(5)	95% CI	21.9 – 29.7	43.0 – 55.1	10.6 – 23.0	2.6 – 9.4
Summer 1983	χ^2	41.9	55.6	15.5	19.9
(9)	95% CI	36.2 – 47.6	50.1 – 61.2	8.3 – 22.8	14.4 – 25.4
Winter 1983-84	χ^2	45.7	39.2	10.6	9.0
(8)	95% CI	39.8 – 51.6	29.5 – 48.8	8.7 – 12.5	2.3 – 15.7
Summer 1984	χ^2	60.4	33.8	19.7	17.7
(8)	95% CI	54.5 – 66.3	24.0 – 43.6	16.1 – 23.3	14.3 – 21.0
Winter 1984-85	χ^2	34.3	13.5	11.1	3.3
(6)	95% CI	22.4 – 46.1	5.1 – 21.8	4.7 – 17.5	2.2 – 4.4
Summer 1985	χ^2	36.3	12.1	12.5	6.9
(9)	95% CI	31.9 – 40.7	7.9 – 16.2	5.4 – 19.6	3.7 – 10.1
Winter 1985-86	χ^2	41.1	22.2	19.6	4.4
(7)	95% CI	36.9 – 45.3	6.2 – 38.2	10.5 – 28.7	1.8 – 7.0

These old field populations also had increased recruitment in early summer (April – May) in some years which was likely related to the decline in breeding activity by mid-summer (see Figure 2).

In terms of mean abundance, Deer Mouse numbers in old field sites ranged from a low of 12.1/ha to a high of 60.4/ha during the four-year study (Table 1). Mean abundance of Deer Mice on the two orchard sites

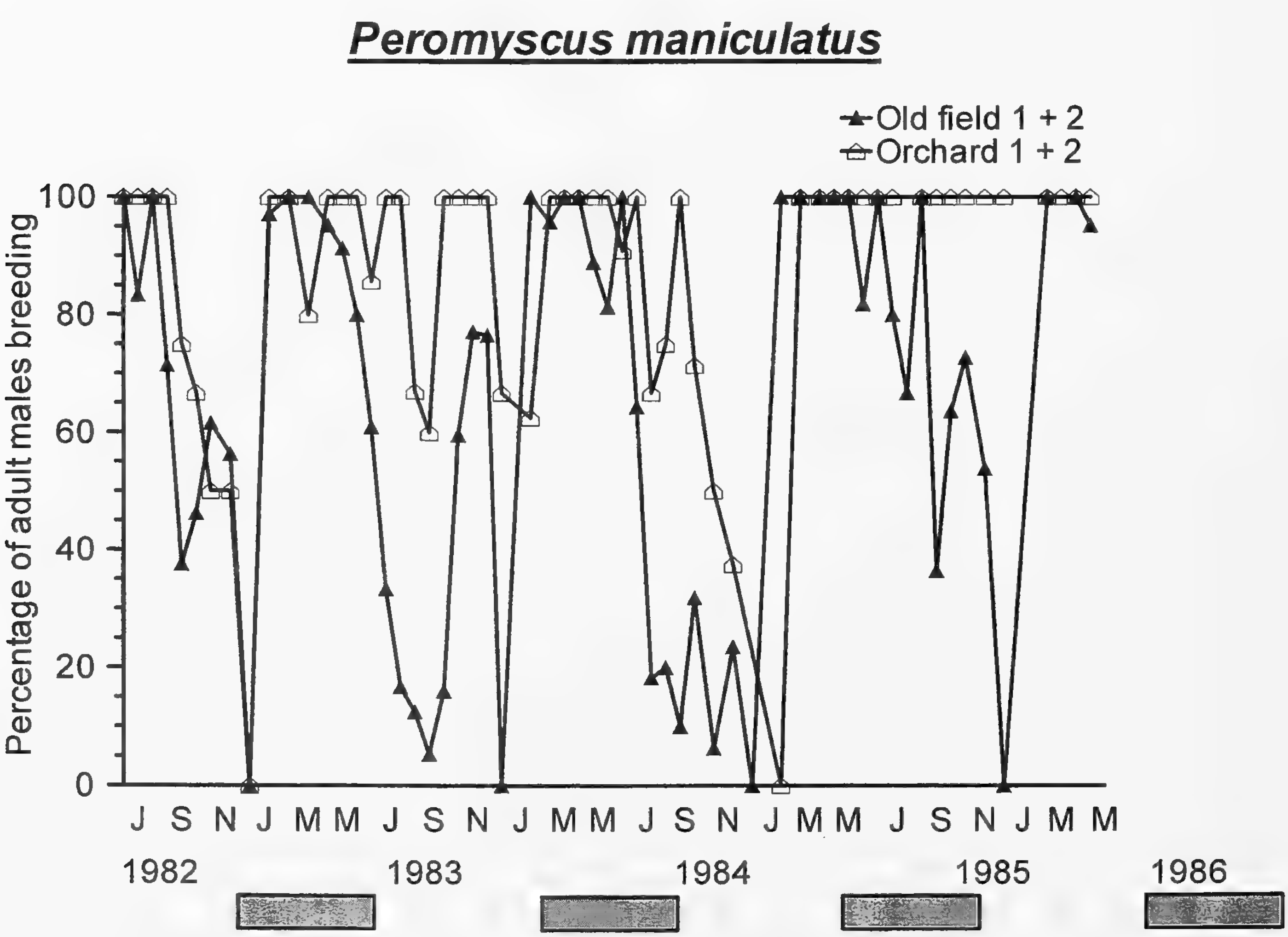

FIGURE 2. Percentage of adult males in reproductive condition for Deer Mice for pooled data in old field and orchard sites during breeding seasons each year. Shaded bars indicate winter periods. Months of year are represented by J = July; S = September; N = November; J = January; M = March; M = May.

ranged from a low density of 3.3/ha to a high of 19.9/ha. Orchard Deer Mice had annual increases in recruitment in early summer with generally higher populations (1.5 times) in summer than winter (Figure 1, Table 1).

Demographic parameters

Adult male Deer Mice commenced breeding in January-February each year and continued up to July in the old field sites and through the summer and autumn months in the orchard sites (Figure 2). This longer breeding season in orchard than old field sites was significantly different in terms of proportion of reproductive males in 3 of 4 years (Table 2). Proportion of breeding female Deer Mice tended to follow this pattern but there was a significant difference between sites in 1984 only (Table 2).

The pattern of recruitment in terms of mean numbers of new Deer Mice was generally similar in old field and orchard sites in both summer and winter periods (Table 3). There was only one period (summer 1985) when an old field – orchard comparison of mean values did not have overlapping 95% CI (Table 3). Thus, productivity within orchard populations of Deer Mice appeared to approach that of old field populations, at least with respect to breeding potential and production of young.

Over the four breeding seasons, early juvenile survival was similar with overall mean values of 3.64 and 2.12 young Deer Mice captured per lactating female in old field and orchard sites, respectively. Mean total survival of Deer Mice was consistently higher in the two old field sites and orchard-1 site than in the orchard-2 site, except in summer 1983 when survival of Deer Mice was significantly lower in the orchard than old field sites (Figure 3).

Mean body mass of Deer Mice was the same or higher in orchard than old field sites during summer and winter periods (Figure 4). Only during winter 1983-1984 did body mass of mice in orchard-2 appear lower than that in the old field sites.

TABLE 2. Proportion of adult male and female Deer Mice in reproductive condition during breeding seasons each year for pooled data in replicate old field and orchard sites and results of Chi-square (χ^2)analysis. Sample size (number of mice) in parentheses. Significant *P* in bold face.

Year	Old field	Orchard	Analysis χ^2	Analysis *P*
Males				
1982	0.62 (84)	0.79 (28)	2.60	0.11
1983	0.67 (367)	0.95 (114)	34.87	**<0.01**
1984	0.67 (253)	0.81 (86)	6.58	**0.01**
1985	0.79 (150)	0.97 (39)	7.21	**<0.01**
Females				
1982	0.26 (69)	0.38 (42)	1.77	0.19
1983	0.30 (209)	0.30 (106)	0.00	1.00
1984	0.40 (182)	0.64 (96)	13.82	**<0.01**
1985	0.47 (103)	0.61 (49)	2.84	0.09

TABLE 3. Mean number of recruits ($\bar{x}$) ± 95% confidence intervals for Deer Mice during summer and winter periods in replicate old field and orchard sites. Sample size (*n* = number of trapping periods) in parentheses.

Period		Old field 1	Old field 2	Orchard 1	Orchard 2
Summer 1982	$\bar{x}$	5.1	13.1	4.6	5.6
(7)	95% CI	2.6 – 7.7	6.2 – 20.1	1.2 – 8.0	2.2 – 8.9
Winter 1982-1983	$\bar{x}$	4.0	6.6	2.8	2.2
(5)	95% CI	1.7 – 6.3	2.6 – 10.6	0.0 – 5.6	1.2 – 3.2
Summer 1983	$\bar{x}$	6.7	10.0	4.9	5.6
(9)	95% CI	2.0 – 11.3	5.0 – 15.0	2.3 – 7.5	2.2 – 8.9
Winter 1983-1984	$\bar{x}$	5.5	3.5	1.9	3.8
(8)	95% CI	1.5 – 9.5	1.6 – 5.4	0.8 – 2.9	1.9 – 5.6
Summer 1984	$\bar{x}$	9.9	5.5	5.5	5.8
(8)	95% CI	7.3 – 12.4	2.5 – 8.5	2.5 – 8.5	3.2 – 8.3
Winter 1984-1985	$\bar{x}$	3.7	1.5	2.2	0.7
(6)	95% CI	0.6 – 6.7	-0.6 – 3.6	-1.0 – 5.3	0.1 – 1.2
Summer 1985	$\bar{x}$	7.8	3.4	3.9	2.0
(9)	95% CI	4.3 – 11.2	2.1 – 4.8	1.9 – 5.9	1.1 – 2.9
Winter 1985-1986	$\bar{x}$	8.6	3.9	7.0	2.1
(7)	95% CI	1.5 – 15.6	0.5 – 7.3	1.3 – 12.7	0.2 – 4.1

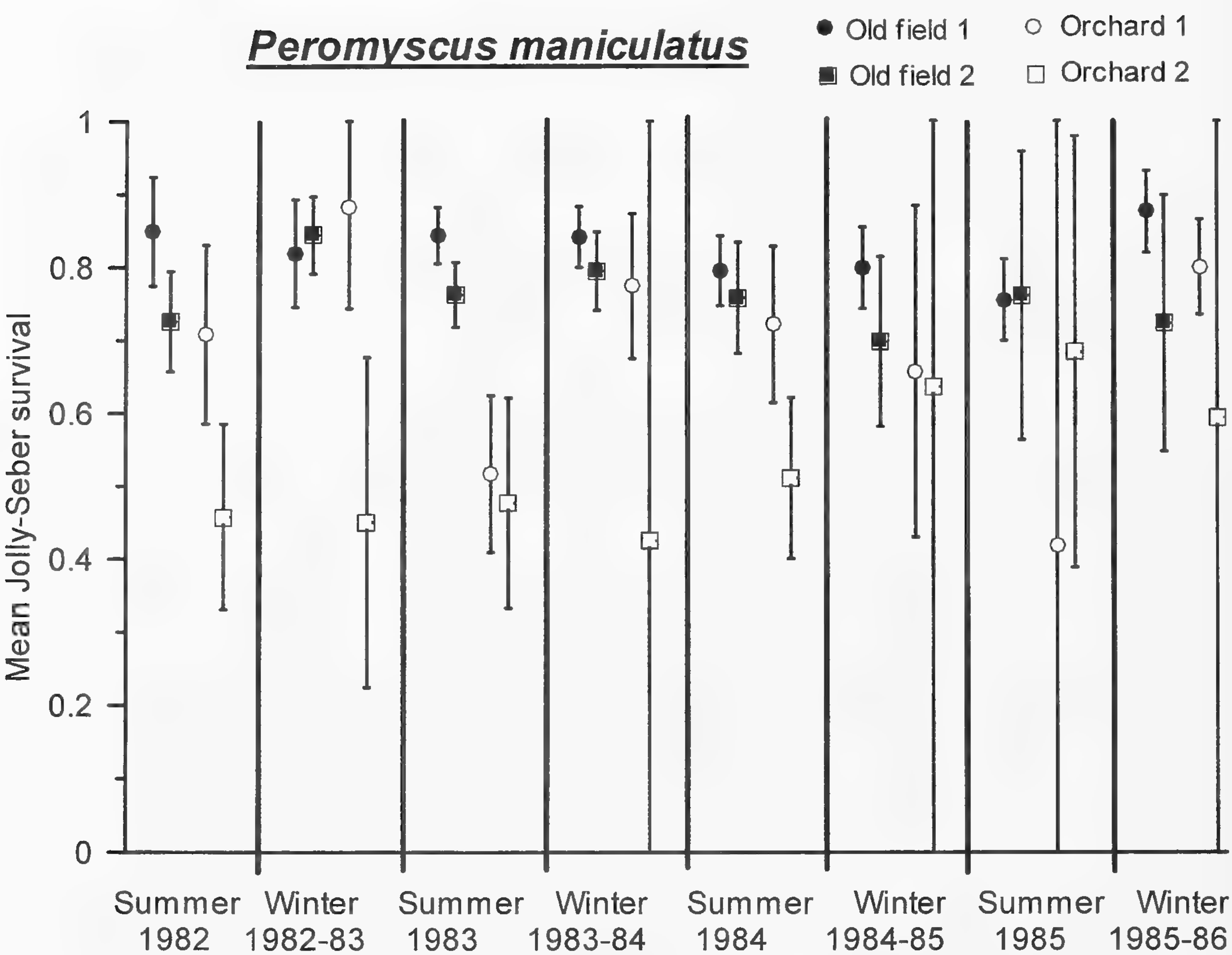

FIGURE 3. Mean Jolly-Seber survival (per 28 days) ± 95% confidence intervals for Deer Mice in replicate old field and orchard sites during summer and winter periods in the study.

Yellow-pine Chipmunk populations

Totals of 137 and 79 individual Yellow-pine Chipmunks were captured in the two old field and two orchard sites, respectively. Only three individual chipmunks were captured in the orchard-2 site during the study. Mean J-S trappability estimates ranged from 30.8% to 63.8% in the old field sites, and from 37.1% to 58.3% in the orchard sites.

Populations of Yellow-pine Chipmunks ranged in mean abundance/ha from 5.6 to 19.0 in old field sites and from 1.9 to 17.5 in the orchard-1 site (Table 4). Mean abundance of Yellow-pine Chipmunks was significantly (non-overlapping 95% confidence intervals) lower in the orchard-1 than old field sites in 1982 and 1985 (Table 4). In terms of population changes over the study, Yellow-pine Chipmunk abundance/ha ranged from 1.0 – 27.0 in old field sites and from 1.0 – 46.3 in the orchard-1 site (Figure 5).

Mean number of Yellow-pine Chipmunk recruits was similar between the old field and orchard-1 sites (Table 4). Mean (± SE) Jolly-Seber survival rates averaged 0.78 ± 0.05 (summer) and 0.96 ± 0.02 (winter) in the old field-1 site and 0.71 ± 0.05 (summer) and 0.91 ± 0.06 (winter) in the orchard-1 site.

Discussion

Deer Mouse and Yellow-pine Chipmunk populations

The pattern of abundance of Deer Mice in our old field sites was somewhat different from that recorded in other old field and perennial grassland studies of *Peromyscus* and *Microtus*. Grant (1972) and Baker (1968) suggested that the Deer Mouse suffers from competition from microtine rodents in perennial grasslands, and is forced to live in woodlands. However, Deer Mouse densities in our studies reached annual peaks ranging from 30.8 to 69.3 animals/ha in the presence of relatively high numbers of Montane Voles (Sullivan et al. 2003). Experimental studies by Grant (1971) and Redfield et al. (1977) concluded that *Microtus* outcompete *Peromyscus* in grassland habitats; however, explanations for this process were not given. Conversely, other studies concluded that competitive interactions among microtine rodents and Deer Mice were unimportant (Gilbert and Krebs 1984; Galindo

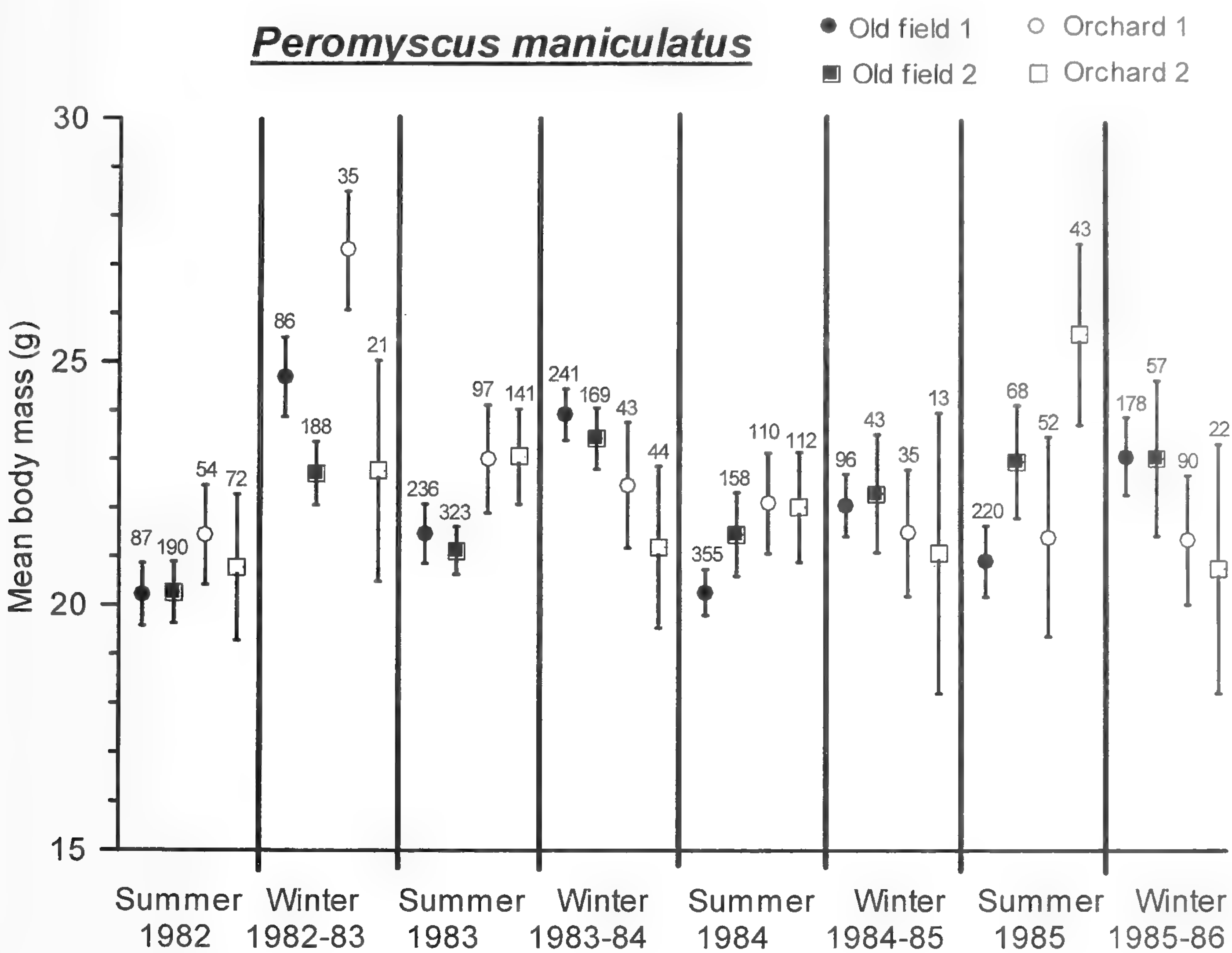

FIGURE 4. Mean body mass (g) ± 95% confidence intervals for Deer Mice in replicate old field and orchard sites during summer and winter periods in the study.

TABLE 4. Mean abundance ($\bar{x}$) and mean number of recruits per ha ($\bar{x}$) (± 95% confidence intervals) for Yellow-pine Chipmunks during non-hibernation periods in replicate old field and orchard sites. Sample size (n = number of trapping periods) in parentheses.

Attribute and period		Old field 1	Old field 2	Orchard 1	Orchard 2
Abundance					
1982	$\bar{x}$	5.6	7.9	1.9	–
(7)	95% CI	3.6 – 7.7	3.8 – 12.0	0.7 – 3.0	–
1983	$\bar{x}$	8.1	11.8	9.3	0.1
(13)	95% CI	5.3 – 10.9	9.8 – 13.8	2.2 – 16.4	–
1984	$\bar{x}$	19.0	8.9	17.5	0.2
(11)	95% CI	15.2 – 22.9	6.2 – 11.6	8.7 – 26.2	–
1985	$\bar{x}$	14.5	9.8	3.6	–
(10)	95% CI	12.1 – 16.9	6.2 – 13.4	1.9 – 5.4	–
Recruits					
1982	$\bar{x}$	1.1	2.7	0.6	–
(7)	95% CI	0.5 – 1.8	0.1 – 5.3	-0.2 – 1.3	–
1983	$\bar{x}$	1.5	1.2	2.3	0.1
(13)	95% CI	0.1 – 3.0	0.0 – 2.4	0.3 – 4.3	–
1984	$\bar{x}$	2.5	0.7	3.4	0.2
(11)	95% CI	1.2 – 3.9	-0.1 – 1.5	0.6 – 6.1	–
1985	$\bar{x}$	1.5	2.1	0.4	–
(10)	95% CI	0.7 – 2.3	0.5 – 3.7	-0.3 – 1.1	–

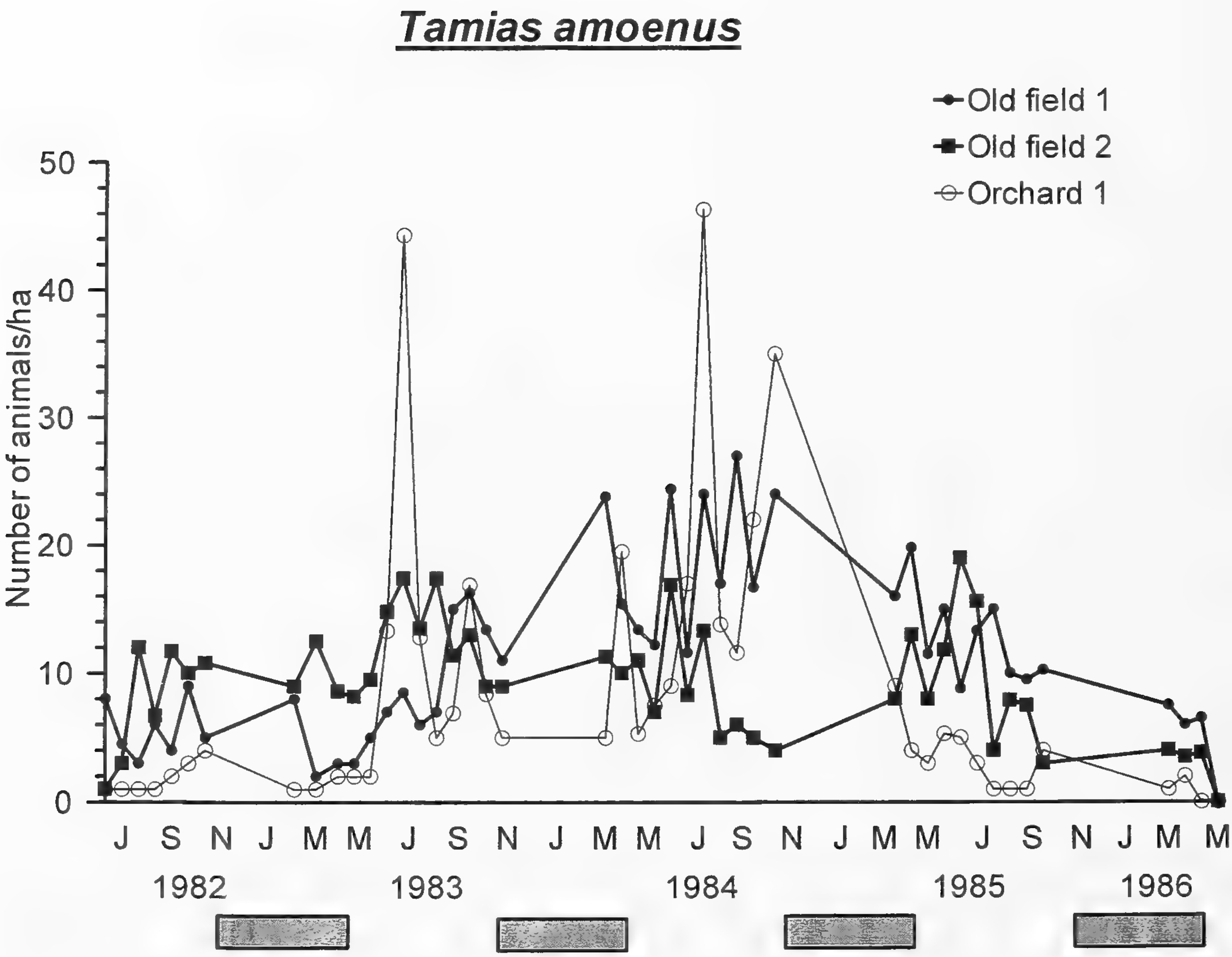

FIGURE 5. Population densities (Jolly-Seber) per ha of Yellow-pine Chipmunks in two old field sites and one orchard site during the study. Shaded bars indicate winter periods. Months of year are represented by J = July; S = September; N = November; J = January; M = March; M = May.

and Krebs 1985). Sullivan and Krebs (1981) reported persistence of Deer Mice with *Microtus* spp. in a grassland habitat. Our densities of Deer Mice were as high as reported in other studies of perennial grassland habitats and orchards (Sullivan and Krebs 1981; Sullivan et al. 1998).

This study is the first detailed investigation of the population dynamics of non-target rodent species in orchards treated with rodenticides for vole control. Populations of Deer Mice in orchard sites showed consistent annual changes in abundance averaging 15.0 animals/ha in summer and 10.1 animals/ha in winter periods. These values were similar to those reported for Montane Voles in these same orchards at 16.5 animals/ha in summer and 21.1 animals/ha in winter (Sullivan et al. 2003). Clearly, Deer Mice seemed productive in the orchard environment, having longer breeding seasons than in the old field sites, and comparable survival of young animals. Winter breeding in Deer Mice has been reported, particularly after substantial mast crops in forests (Wolff 1996) or in supplemental food studies (Taitt 1981). Food resources appeared sufficient to support breeding mice during winter periods and at body masses comparable to old field populations during most periods. These orchards received regular inputs of fertilizer and irrigation, and hence likely produced relatively "rich" habitats in terms of plant production and invertebrate biomass. Mean overall survival of Deer Mice in orchards was poor, in at least one of the sites, relative to old field populations. A lack of vegetative cover may have contributed to greater predation by raptors, weasels (*Mustela* spp.), and Coyotes (*Canis latrans*).

Our orchards were situated in a mosaic of different varieties and age classes of orchards and vineyards with adjacent natural habitats of sagebrush and Ponderosa Pine (*Pinus ponderosa*). As discussed by Sullivan et al. (1998) for their study in this same mosaic, it was possible that our relatively high numbers of Deer Mice (and Yellow-pine Chipmunks) in orchards may have represented transients or animals who lived in nearby sage-pine areas. However, a comprehensive analysis of transient and resident animals suggested strongly that these rodents very likely lived in the actual

orchard units (Sullivan et al. 1998). There was no reason to assume that our animal populations behaved differently, and hence our population estimates were considered accurate.

The prediction of the hypothesis that population dynamics of Deer Mice and Yellow-pine Chipmunks would be enhanced in old field compared with orchard habitats is partially accepted. Abundance, recruitment, and overall survival of Deer Mice were higher in old field than orchard sites. However, proportion of breeding animals and length of breeding seasons were greater in the orchard sites. Early juvenile survival and body mass were similar between sites for Deer Mice. Similarly, the general lack of differences in abundance (except in 1982 and 1985) and recruits for Yellow-pine Chipmunks between sites (albeit for one replicate only) also contradicted our prediction.

These rodent species should be able to maintain their population levels in association with *Microtus* in these habitats. Traditional methods of vole control (rodenticides) seem to have had little effect on these two non-target species in the orchard sites. The higher abundance of Deer Mice, and sometimes Yellow-pine Chipmunks, in the old field than orchard sites was more likely a function of habitat quality than exposure to rodenticides. Consequently, Deer Mice and Yellow-pine Chipmunks may assist integrated pest management in orchards because both species persisted in this managed habitat and their consumption of seeds and invertebrates could provide some degree of assistance in reducing weed and insect pests. In addition, as prey species, they may attract a greater number of predators to these sites. A total of six small mammal species was recorded in these orchards, which suggests that these agro-ecosystems and adjacent natural lands help contribute to a diversity of habitats in this agrarian landscape.

Acknowledgments

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Density and Survival of Lady Beetles (Coccinellidae) in Overwintering Sites in Manitoba*

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Turnock, W. J., and I. L. Wise. 2004. Density and survival of Lady Beetles (Coccinellidae) in overwintering sites in Manitoba. Canadian Field-Naturalist 118(3): 309-317.

The densities of lady beetles, Coccinellidae, overwintering as adults (adults per m^2) in leaf litter collected in late October for two years in a beach-ridge forest on the south shore of Lake Manitoba were 56.4 for the Thirteen-spotted Lady Beetle, *Hippodamia tredecimpunctata* (Say), 38.3 for the Seven-spotted Lady Beetle, *Coccinella septempunctata* (L.), 7.7 for the Transverse Lady Beetle, *Coccinella transversoguttata richardsonii* Brown, 1.6 for the Convergent Lady Beetle, *Hippodamia convergens* Guerin, and 0.6 for the Parenthesis Lady Beetle, *Hippodamia parenthesis* (Say). The mean overwintering survival for these species was 0.254, 0.036, 0.023, 0.0, and 0.0, respectively. The density of overwintering coccinellids was highest near the margins of the forest, particularly on the beach side, where beetles from shore appear to have entered the forest. The mean density over 3 years (2.9 per m^2) of all coccinellid species in November in the litter under a remnant grove of riverbank forest in Winnipeg, was lower than in the beach-ridge forest (104.8 per m^2), but their survival (0.460) was higher than in the beach-ridge forest (0.154). More species of coccinellids were found in the samples from the riverbank forest than from the beach-ridge forest.

Key Words: Lady Beetles, Coccinellidae, leaf litter, beach-ridge forest, overwintering sites, Lake Manitoba, Red River.

The overwintering sites of north-temperate zone coccinellids include leaf litter, grass tufts, bark crevices, stone piles, and rock clefts (Hodek and Honěk 1996). Adults of some species migrate long distances to hibernate at high elevations, and even those which move only locally seem to be attracted to even slightly higher elevations and vertical silhouettes. In Bohemia and Moravia, *Coccinella septempunctata* L. (C7) prefers elevated places, but also hibernates in refuges among cultivated areas and does not migrate long distances (Hodek 1960). In southern Manitoba, where much of the land is flat and cultivated, it is generally believed that lady beetles overwinter in the leaf litter under trees in field shelterbelts, farmsteads and urban plantings, along the shores of streams and lakes, and in "bluffs" (groves of trees on uncultivated land). The species occurrence, density, and survival of coccinellids in most of these overwintering sites have not been studied.

Large numbers of pre-hibernating coccinellids are washed ashore in some years on Manitoba lakes, usually in late August to early October (Lee 1980; Turnock et al. 2003). These beetles usually fly away soon after, to complete their search for hibernating sites, and do not often walk into the adjacent beach-ridge forest. Once, on 1 November 1978, beetles (mainly *H. convergens*) were washed ashore, but subsequent cold weather forced them to remain near the beach, where few survived the winter (Turnock and Turnock 1979).

In this paper, the density, distribution, species composition, and overwintering survival of coccinellids in the litter under a beach-ridge forest are compared with the density and survival of coccinellids in the litter under a riverbank forest.

Methods

Beach-Ridge Forest. The abundance and species composition of coccinellids overwintering in the surface litter and soil under a beach-ridge forest on the south shore of Lake Manitoba at the Delta Marsh Field Station (University of Manitoba), 50°11'N, 98°23'W, about 120 km WNW of Winnipeg, were recorded. The shore is a sand beach with a forested barrier-beach ridge formed by the reworking of alluvial sand deposits. This beach ridge, about 60 m wide, supports a mature deciduous forest of Manitoba Maple (*Acer negundo* L.), Green Ash (*Fraxinus pennsylvanica* Marsh.), Plains Cottonwood (*Populus deltoides* Marsh.), and Peachleaf Willow (*Salix amagdaloides* Anderss.) (Kenkel 1986). The ridge has its highest elevation 5-10 m from the top of the foreshore and slopes down about 50 m to the marsh. A road about 10 m wide along the south edge of the beach ridge separates the forest from the marsh. Samples were taken along five transects, 20 m apart, perpendicular to the beach. Six samples were taken along each transect at 1, 6, 11, 21, 31, and 41 m from the top of the foreshore, where the beach ended and the beach-ridge forest began. A sample of the leaf litter and soil above the sandy parent material, 0.25 m^2 and 5-10 cm deep, was collected at each of the 30 locations. Samples were collected after beetle flight had ceased, on 22 October 1992 and 27 October 1993. Each sample was bagged, sorted by

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hand to remove the beetles, and the species and number of coccinellids were recorded.

The numbers and species of coccinellids emerging in the spring were determined from cone traps, each covering a surface area of 0.1028 m^2 (Turnock et al. 1987). One trap was set into the litter at each of the 30 locations, near the place where a litter sample had been collected the previous autumn. The traps were set out at each location in late April or May, depending on the disappearance of snow, in 1993, 1994, and 1995. The traps at the apex of the cones were emptied at regular intervals, and the coccinellids identified to species and counted.

Riverbank Forest. The overwintering of coccinellids in a remnant grove of riverbank forest along the Red River at the University of Manitoba, Winnipeg, Manitoba, was determined from records of the insects found in litter samples and emergence traps used to study the overwintering of flea beetles (Chrysomelidae) (Turnock et al. 1987). The grove of trees, about 1.3 ha in area, included Bur Oak (*Quercus macrocarpa* Michx.), American Elm (*Ulmus americana*), Manitoba Maple, Green Ash, Black Ash (*Fraxinus nigra* Marsh.), and Basswood (*Tilia americana* L.). In this grove, 50 litter samples, each 0.25 m^2, <10 cm deep, were collected in the autumn of the years 1980-1982, and in the springs of 1980, 1981, and 1983. The samples were taken at 10 m intervals along five transects running north to south through the grove. Spring emergence was sampled by 100 cone traps, each covering 0.1028 m^2, in 1980 and 1981. Two traps were located at 10 m intervals along each transect, one on each side of the site of a litter sample, as described by Turnock et al. (1987). For coccinellids, only the total number collected in each sampling period was recorded, except in the litter samples of 3 November 1982, where the species were identified but their numbers were not recorded.

Results

Beach-Ridge Forest. The dominant species in all collections were *H. tredecimpunctata*, *C. septempunctata*, and *Coccinella transversoguttata*. In the autumn litter samples in 1992 (n = 653) and 1993 (n = 918) coccinellid relative abundances were: 0.54/0.54 (*H. tredecimpunctata*); 0.36/0.37 (*C. septempunctata*); 0.08/0.07 (*C. transversoguttata*); 0.01/0.02 *H. convergens*; and 0.004/0.001 *H. parenthesis* (Say). In the spring emergence samples, the relative abundances of each species in 1993/94/95 were: *H. tredecimpunctata* – 0.95/0.78/0.92; *C. septempunctata* – 0.04/0.19/0.06; and *C. transversoguttata* – 0.02/0/0. Neither *H. convergens* nor *H. parenthesis* were found in the spring samples. The distribution of numbers per sample of *H. tredecimpunctata* and *C. septempunctata* was skewed in both the autumn litter samples and the spring emergence samples, with most samples containing 0, 1, or 2 beetles (Figure 1).

The mean density per m^2 of coccinellids in the autumn was 87.1 in 1992 and 122.4 in 1993, and 8.5 and 11.7 in the following springs. The density of coccinellids in the autumn was generally higher on the margins of the forest, but it varied among species (Figure 2). The numbers of *H. tredecimpunctata* were highest near the beach margin in 1993, but they were higher near the marsh margin in 1992. The density of both *C. septempunctata* and *C. transversoguttata* was higher near the beach margin in both years, with only a slight increase along the marsh margin. These patterns suggest that most of the *C. septempunctata* and *C. transversoguttata* found in the litter near the beach were from aggregations that had washed ashore (Turnock et al. 2003). *Hippodamia tredecimpunctata* seems mainly to have come from the beach in 1993, but in 1992 more appeared to have come across the marsh to the edge of the forest.

The proportion of living beetles in the autumn litter samples differed little between years, 81.3% in 1992 (n = 653) and 81.4 % (n = 913) in 1993 (Table 1). The mean proportion of living beetles, by species for both years, was: *H. tredecimpunctata* = 0.963 (n = 847); *C. septempunctata* = 0.729 (n = 575); *C. transversoguttata* = 0.250 (n = 116); *H. convergens* = 0.458 (n = 24); and *H. parenthesis* = 0.500 (n = 4). Survival of all species was lowest adjacent to the beach and increased toward the edge of the marsh (Figure 3). The decreased survival in the forest edge near the beach was probably caused by the burial of overwintering beetles by sand blown off the beach by strong winds.

Coccinellids emerged from the leaf litter during May and early June in traps throughout the beach-ridge. Most of the beetles (98%, n = 187) were of two species, *H. tredecimpunctata* and *C. septempunctata*. The mean density per m^2 of emerging coccinellids in 1993 to 1995 was: 17.5, 9.1, 27.9 for *H. tredecimpunctata*; 0.65, 2.3, 1.9 for *C. septempunctata*; and 0.32, 0, 0 for *C. transversoguttata*. The pattern of higher densities near the margins of the forest was less prominent in the spring than in the autumn (Figures 2 and 4). The density of emerging beetles was <20 per m^2 except at distances from the beach of 1 m in 1995, 31 m in 1994, and 41 m in 1993.

The mean overwintering survival (density spring/density autumn) in the beach-ridge forest for *H. tredecimpunctata* was 0.370 in the winter of 1992-1993, and 0.139 for 1993-1994 (Table 1). The survival ratios over the same two winters for *C. septempunctata* were 0.021 and 0.051, and for all coccinellids, 0.212 and 0.096. The survival of *H. tredecimpunctata* was quite variable with position within the forest (Figure 5). Overwintering survival of all species was very low at 1 m from the beach margin of the forest, where drifting sand often covered the leaf litter. However, the overwintering survival did not significantly differ among years, density of coccinellids in the autumn, or distance

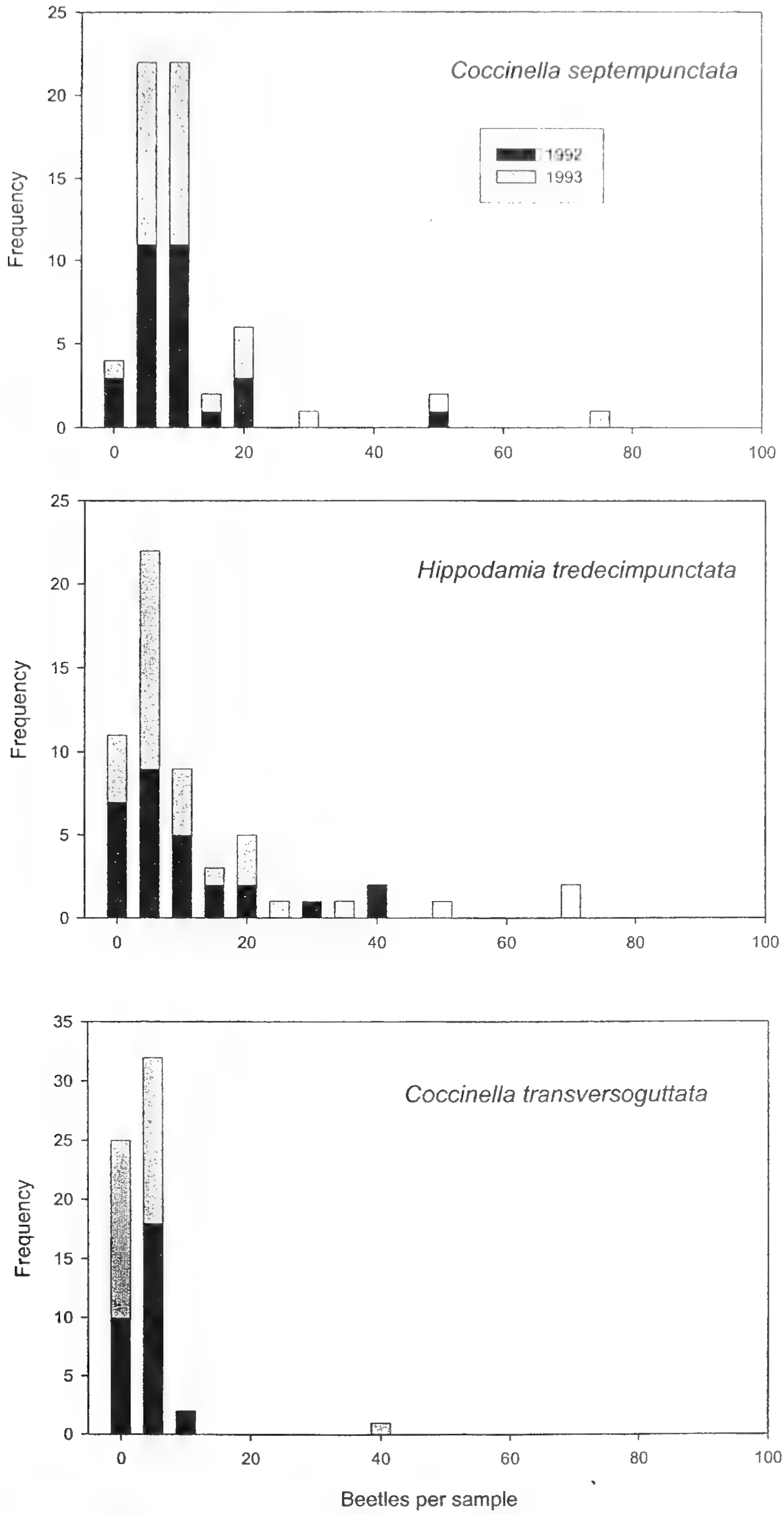

FIGURE 1. Frequency distribution of numbers of coccinellids, *Hippodamia tredecimpunctata*, *Coccinella septempunctata*, and *Coccinella transversoguttata*, per sample of litter (0.25 m^2 × 5-10 cm deep) from the floor of the beach-ridge forest at the Delta Marsh Field Station, Manitoba, in late October of 1992 and 1993. n = 60 for each species.

TABLE 1. The mean numbers (N) per m^2 in autumn litter samples and spring emergence samples, the proportion of living beetles in the autumn samples, and the overwintering survival (density spring emergents/density in autumn), for *Coccinella septempunctata* (C7), *Hippodamia tredecimpunctata* (H13), *C. transversoguttata* (CT), *H. convergens* (HC), and *H. parenthesis* (*HP*), and all coccinellids in the beach-ridge forest at the Delta Marsh Field Station.

Species		1992 Autumn	1993 Spring	1993 Autumn	1994 Spring	1995 Spring
H13	N/m^2	47.3	17.5	65.6	9.1	27.9
	Survival	0.95	0.37	0.97	0.14	–
	N	355	54	492	28	86
C7	N/m^2	31.3	0.65	45.3	2.3	1.9
	Survival	0.72	0.02	0.73	0.05	–
	N	235	2	340	7	6
CT	N/m^2	6.9	0.32	8.5	0	0
	Survival	0.37	0.05	0.16	0	–
	N	52	1	64	0	0
HC	N/m^2	101	0	2.1	0	0
	Survival	0.38	0	0.5	0	–
	N	8	0	16	0	0
HP	N/m^2	0.4	0	0.13	0	0
	Survival	0.67	0	1	0	–
	N	3	0	1	0	0
All	N/m^2	87.1	18.5	122.4	11.7	30.5
	Survival	0.81	0.21	0.81	0.1	–
	N	653	57	913	36*	94*

*Includes one specimen of *Anistosticta bitriangularis* in 1994 and two specimens of *Calvia quatuordecimguttata* in 1995.

from the beach (analysis of variance, proc glm, SAS Inst. Inc. <www.sas.com>). The high survival of *H. tredecimpunctata* at several locations likely reflects the placing of the emergence traps over local aggregations of beetles in the litter, as does a single record of high survival of *C. septempunctata*.

Riverbank Forest. The litter samples collected on 3 November 1982 contained nine species of coccinellids: *Stethorus punctum* (LeConte), *Scymnus (Pullus) brullei* Muls., *Hyperaspis benedetti* (Say), *Chilocorus stigma* Say, *H. tredecimpunctata, Anatis labiculata* (Say), *Adalia bipunctata* L., *C. transversoguttata*, and *Psyllobora virginimaculata* (Say). The mean density of all coccinellid species in the autumn litter collections of 1980-1982 (n = 110) was 2.9 per m^2 (2.0-4.3), vs. 4.4 (1.5- 10.4) in the spring litter collections (n = 172) of 1980, 1981, and 1983. Overwintering survival, calculated by dividing the number of living beetles in the spring litter samples by the total number of beetles in the autumn samples, was 76% for the winter of 1980-1981 and 43% for the winter of 1982-1983. Survival during the winter of 1980-1981 was lower, 49%, when the spring density, 0.97 per m^2, was based on captures in the emergence traps (n = 10).

Discussion and Conclusions

The studies of coccinellid density and survival in three overwintering sites in southern Manitoba differ in location, years, and sampling design. However, the results of some comparisons may be helpful to future investigators of site selection and survival by overwintering coccinellids. In the autumn, more overwintering lady beetles were found in a beach-ridge forest on the shores of Lake Manitoba in 1992 and 1993 than in a riverbank forest in Winnipeg in 1980 to 1981. The difference in the density between the two sites may have been related to differences in the populations of lady beetles in the years sampled. Another factor could be the availability of overwintering sites in the two areas. The beach-ridge forest was located in an intensively-farmed area with few treed areas, whereas the riverbank forest was near suburban Winnipeg, where trees were more abundant. Beetles washed ashore on the beach contributed to the number overwintering in the beach-ridge forest in 1993, but in 1992 more beetles seem to have entered the forest from the side away from the beach.

The beach-ridge forest, despite higher initial densities, had fewer species and fewer beetles emerging in the spring than in the riverbank forest, because of lower overwintering survival. Overwintering survival by beetles may be related to their need for moisture (Hodek and Honěk 1996). The litter under the riverbank forest was thicker and lay upon a clay soil, thus providing a moister environment than the thinner litter on a sandy soil under the beach-ridge forest.

The limited sampling by Turnock and Turnock (1979) on the shores of Lake Manitoba, following a very late flight (1 November) and aggregation of beetles, indicated few beetles survived the winter (2% of 1002 per m^2 trapped in the beach debris). Even this level of survival is surprising, because beach debris usually is pounded and buried by high water, large

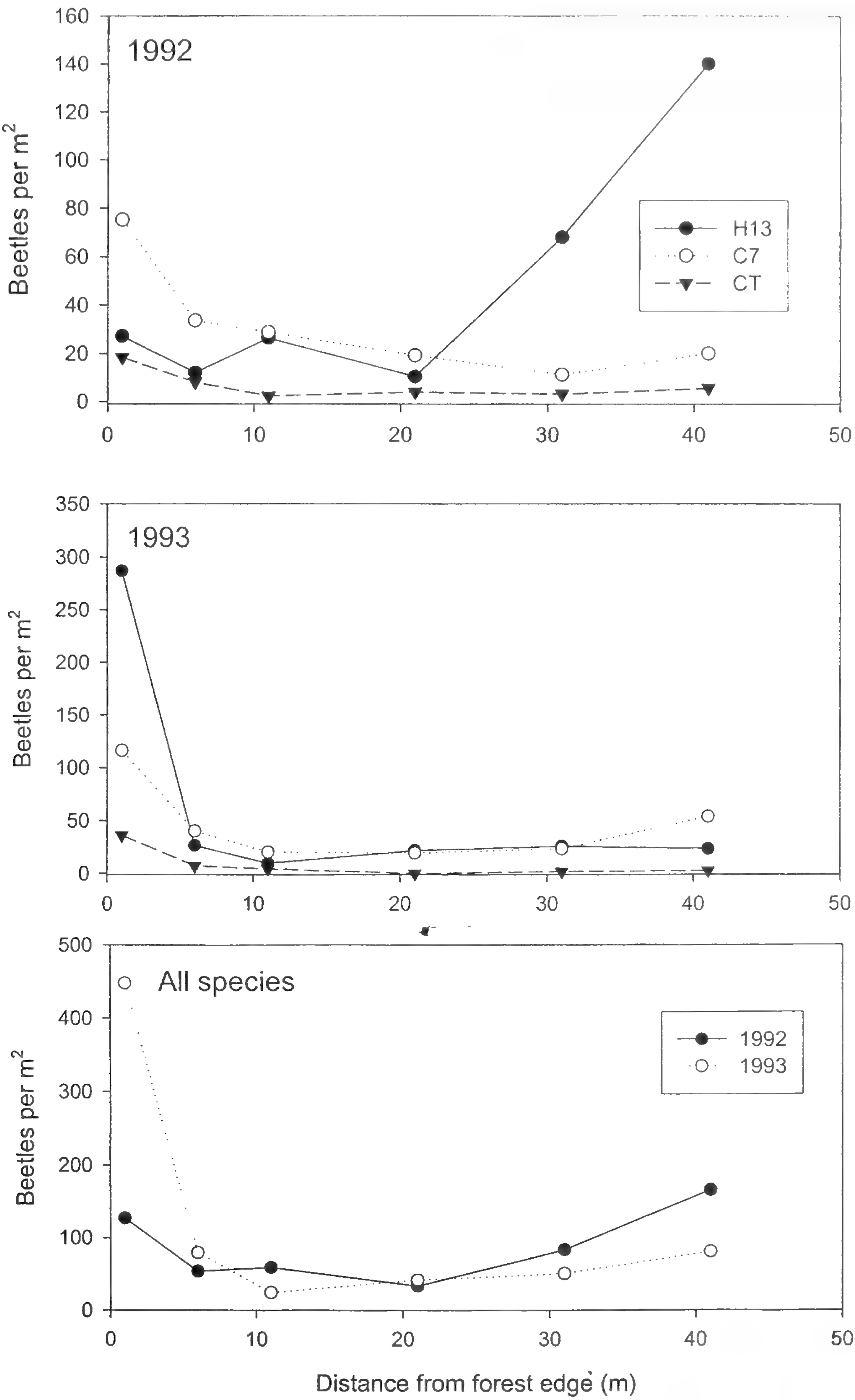

FIGURE 2. Mean density per m² of *Hippodamia tredecimpunctata*, *Coccinella septempunctata*, *Coccinella transversoguttata*, and all coccinellids, in forest litter samples collected at various distances from the forest edge next to the beach in late October 1992 and 1993 at the Delta Marsh Field Station.

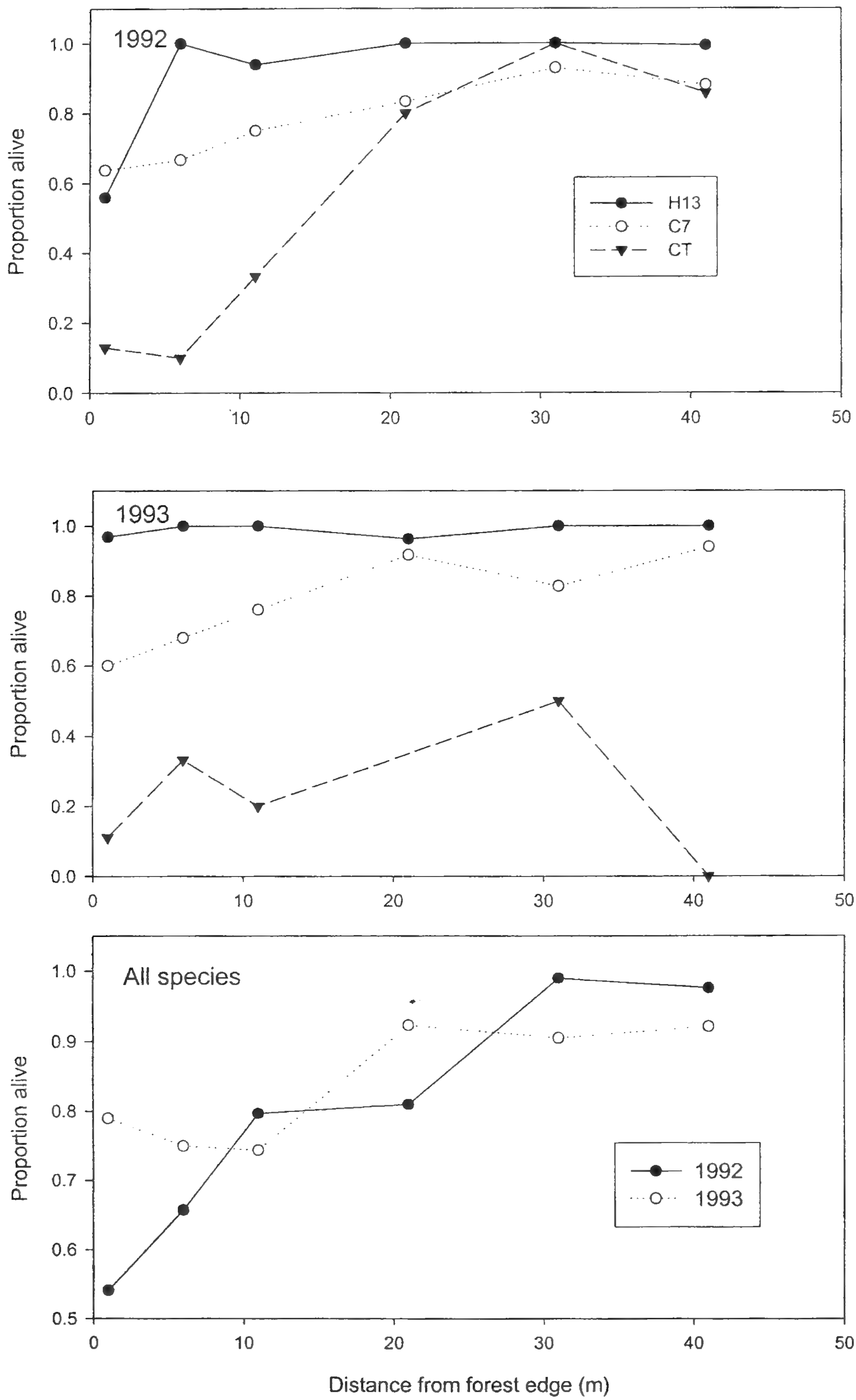

FIGURE 3. Proportion of live individuals of *Hippodamia tredecimpunctata* (H13), *Coccinella septempunctata* (C7), *Coccinella transversoguttata* (CT), and all coccinellids, in litter samples taken at different distances from forest edge next to the beach in late October of 1992 and 1993.

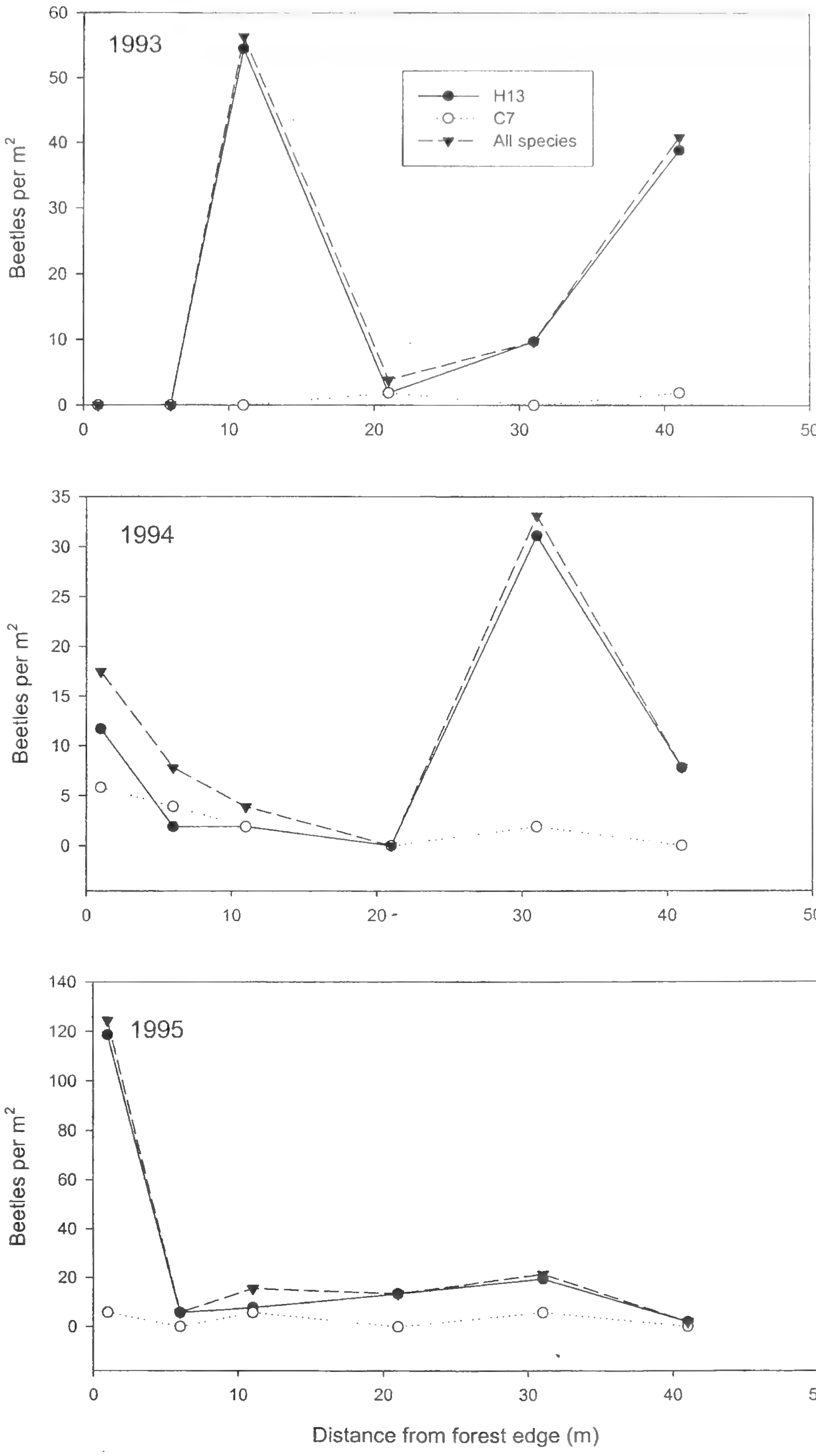

FIGURE 4. Mean density per m^2 of *Hippodamia tredecimpunctata* (H13), *Coccinella septempunctata* (C7), and all coccinellids, in emergence trap samples collected at different distances from the forest edge next to the beach. The samples were collected from emergence cones placed over the litter in May of 1993, 1994, and 1995.

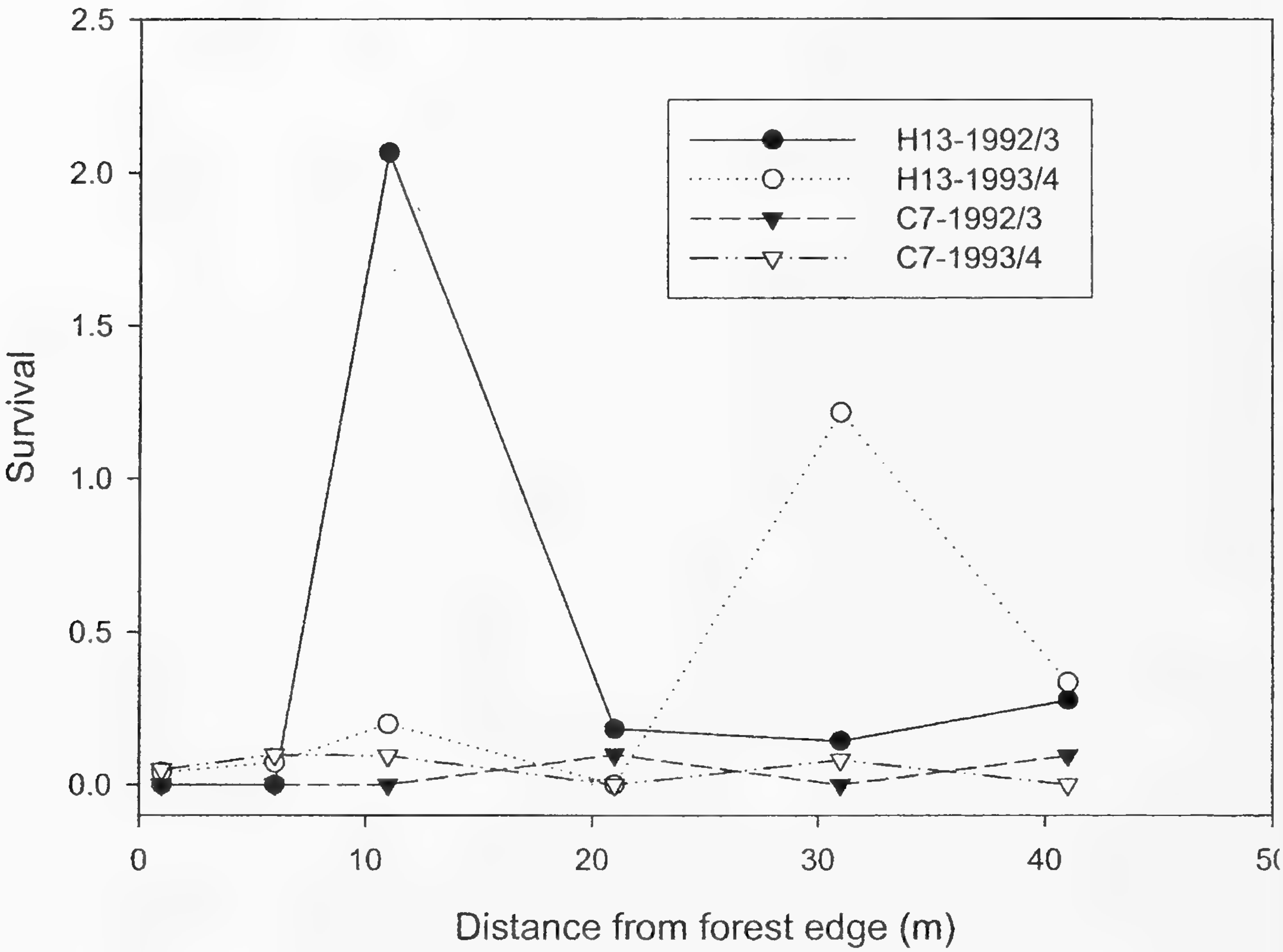

FIGURE 5. Mean overwintering survival ratios for *Hippodamia tredecimpunctata* (H13), and *Coccinella septempunctata* (C7), for the winters of 1992-1993 and 1993-1994 in forest litter on the beach ridge at different distances from the forest edge next to the beach at the Delta Marsh Field Station.

waves, and ice chunks from violent autumn and spring storms. In this study the top of the foreshore, where a covering of aspen leaves had accumulated on the sand, had 74 beetles per m^2 and overwintering survival was 53%. This location is not likely to be a suitable overwintering site in most years because of high water and waves. The grassy backshore, with little litter, had 28 beetles per m^2, of which 18% survived the winter. The foreshore of the sandy beaches and even the shallow litter in the sparse beach-ridge forest of Trembling Aspen, *Populus tremuloides* Michx., do not appear to be selected by coccinellids for overwintering. Exceptions can occur when beetles washed ashore after unusually late autumn flights aggregate on the beach when subsequent temperatures are too cool to allow flight, but warm enough to allow limited walking up the beach to the backshore. In these cases the beach-ridge forest, even if unsuitable, is mainly a "last-chance" overwintering site for these beetles.

Four species of coccinellids, *H. tredecimpunctata*, *C. septempunctata*, *C. transversoguttata*, and *H. convergens* (in order of relative abundance) were found in both years in autumn litter samples in the beach-ridge forest, but only the first two species were found in the spring emergence samples in all three years. More *H. tredecimpunctata* (14 and 38%) survived over winter than *C. septempunctata* (3 and 5%) or *C. transversoguttata* (5 and 0%). This level of survival of *C. septempunctata* is much lower than the 97% survival of *C. septempunctata* that had been covered with litter in experimental cages at Edmonton, Alberta (Ryan and Acorn 1999).

Although in Europe *C. septempunctata* does not migrate long distances to hibernate (Hodek 1960), large flights of this species occur in both autumn and spring, as shown by the numbers of this species that are found in the aggregations washed ashore on the shores of the lakes (Turnock et al. 2003).

Southern Manitoba is mostly cultivated and has a flat terrain, so potential overwintering sites are limited to leaf litter under trees. These habitats probably are both attractive and suitable for the hibernation of coccinellids, but without information on the preferred overwintering sites in this area, the true level of overwintering survival by native and introduced species cannot be compared.

Acknowledgments

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Description of Age-0 Round Goby, *Neogobius melanostomus* Pallas (Gobiidae), and Ecotone Utilisation in St. Clair Lowland Waters, Ontario

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Leslie, John K., and Charles A. Timmins. 2004. Description of age-0 Round Goby, *Neogobius melanostomus* Pallas (Gobiidae), and ecotone utilisation in St. Clair lowland waters, Ontario. Canadian Field-Naturalist 118(3): 318-325.

Early developmental stages and ecotone utilisation of the non-indigenous Round Goby, *Neogobius melanostomus* (Pallas, 1811), are described and illustrated. Fish (5-40 mm) were collected in coarse gravel, rocks and debris in the St. Clair River/Lake system, Ontario, in 1994-2000. The Round Goby hatches at about 5 mm with black eyes, flexed urostyle, and developed fins and digestive system. Distinguishing characters include large head, dorsolateral eyes, large fan-shaped pectoral fins, two dorsal fins, fused thoracic pelvic fins and a distinct black spot on the posterior of the spinous dorsal fin. Modal counts for preanal, postanal, and total myomeres were 12, 19, and 31, respectively.

Key Words: Round Goby, *Neogobius melanostomus,* St. Clair aquatic ecosystem, age-0, morphometry, habitat, Ontario.

Gobiidae, the largest family of marine fishes, has been found in fresh waters of all continents (Nelson 1984) except Antarctica. None of 68 species endemic to North America is native to the Great Lakes, where two introduced species, the Round Goby, *Neogobius melanostomus* (Pallas, 1811) and the Tubenose Goby, *Proterorhinus marmoratus* (Pallas, 1811), recently became established. These fishes originate in the Ponto-Caspian region (Caspian, Azov and Black seas and Sea of Marmara). International ships' ballast was assumed the most probable means by which Round Goby eggs and/or postembryonic stages were transferred from the Black Sea to the Great Lakes (Crossman et al. 1992; Jude et al. 1992). Since its arrival in the mid-late 1980s the relatively innocuous Tubenose Goby has not proliferated beyond the St. Clair-western Lake Erie ecosystem (Leslie et al. 2002). In contrast, the aggressive, eurytopic Round Goby has diffused extensively and is now one of the most abundant fish in the Great Lakes basin. Apparently, repetitive spawning and habitat requirements of this fish conflict with our native species (Dubs and Corkum 1996), some of which they may supplant.

The Round Goby is a guarding cavity spawner with a life span of 4-5 years (Miller 1986). Spawning season is typically from spring to late summer. Rocks, gravel, solid objects with crevices and submersed plants are used for egg deposition (Miller 1986; Skóra 1997*). Whereas literature abounds on the ecology of adults, information on postembryonic fish is rare. Eggs and early developmental stages in southern Russia and Ukraine have been described by Moskal'kova (1967), Kalinina (1976), and Koblickaja (1981). This report presents information on aspects of taxonomy and ecotone utilisation of age-0 Round Gobies in the Great Lakes and considers possible effects the species may have on the aquatic community in general and native fishes in particular.

Study Area

Eggs and age-0 fish were collected at numerous locations at the shore of the St. Clair River, Ontario, various sites along the southeastern shore of Lake St. Clair, and in Duck Creek (42°17'N, 82°35'W), a low gradient stream tributary to Lake St. Clair (Figure 1). Duck Creek is a disturbed system draining a small area in one of the most highly cultivated agricultural regions in Canada. It is approximately 9 km long and 10-15 m wide near its mouth, where most specimens were collected. Mid-stream depth ranges from 1.2 to 1.6 m. In April to November 1995, mean conductivity was 487 µS/cm and Secchi disc depth 0.3 ± 0.1 m, reflecting high suspended particulate load due to run-off from cropland. Substrate at the sampling site is mainly alluvium, with clay and scattered debris of human origin at the base of 1-4 m high stream banks. However, age-0 Round Gobies were found only on a small gravelled area at the base of a railway bridge.

Duck Creek has a large diverse, albeit transient, fish assemblage of at least 41 species (Leslie and Timmins 1998) dominated by Gizzard Shad *Dorosoma cepedianum,* Bluntnose Minnow *Pimephales notatus,* Spottail Shiner *Notropis hudsonius,* and Bluegill *Lepomis macrochirus*. Submersed plants near the collection site include Pondweed *Potamogeton* spp., Eelgrass *Vallisneria americana*, Canada Waterweed *Elodea canadensis*, Eurasian Milfoil *Myriophyllum spicatum*, and Curly Pondweed *Potamogeton crispus.* Arrowhead *Sagittaria* sp., Sedge *Carex* sp., Cattail *Typha* spp., and Bulrush *Scirpus* spp. were abundant emergent species.

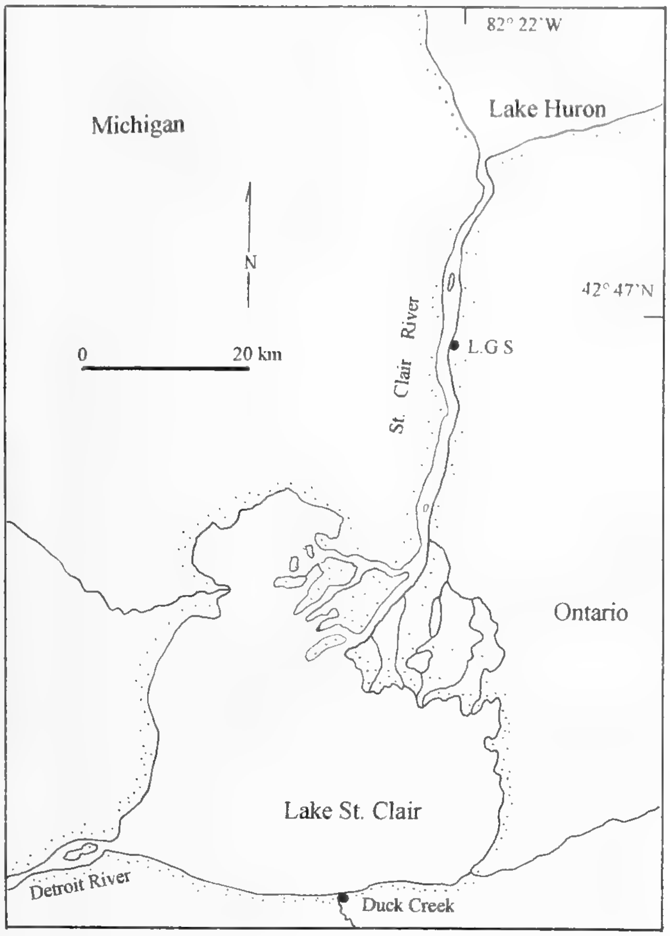

FIGURE 1. Main sites where age-0 *Neogobius melanostomus* were collected in the St. Clair River-Lake ecosystem in 1994-2000: LGS (Lambton Generating Station) and Duck Creek.

Round Goby eggs and age-0 developmental stages as well as numerous co-occurring fishes were found at various locations at the shore of the St. Clair River, mainly in dilute condenser cooling water discharge of Lambton Generating Station (LGS) (42°47'N, 82°22'W). Random fish collections took place at LGS (Figure 1) each year between April and November 1994-2000 over a shoreline stabilised with debris, limestone boulders and rocks 0.3-1.0 m in longest dimension. This formation extends 4 m from shore on a natural substrate of sand. Most common fish species collected with age-0 Round Gobies in the St. Clair River include age-0 White Sucker *Catostomus commersoni*, Alewife *Alosa pseudoharengus,* Brook Silverside *Labidesthes sicculus,* Rainbow Darter *Etheostoma caeruleum,* Iowa Darter *Etheostoma exile,* Johnny Darter *Etheostoma nigrum,* Spottail Shiner, and Emerald Shiner *Notropis atherinoides.* Of these species, guarding speleophils Rainbow Darter, Iowa Darter, and Johnny Darter utilise common ecotones and probably compete with gobies for food and shelter.

Methods

A bulging larval fish beach seine (4 m long, 1 m wide, mesh 0.4 mm) was necessary for capture of recently hatched gobies, which only emerged from protective crevices when the bottom of the seine disturbed the substrate. Two flat seines, 3 m long, 1 m wide (3 mm mesh), and 6 m long, 1 m wide (6 mm mesh) were used to sample young and adult gobies and co-occurring species. All seine hauls took place repeatedly in contact with gravel at the base of a railway bridge over Duck Creek.

In the St. Clair River, clusters of eggs attached to rocks or human artefacts such as discarded sewer pipe were preserved intact with 5-10% formalin and enumerated in the laboratory. Water temperature, specific conductivity, water transparency, substrate characteristics, and co-occurring fishes were recorded at all sampling locations except four that were devoid of cover and fishes.

Fish were preserved in a 12:1 solution of 80% ethanol and glycerin, respectively, and stored at room temperature (22-25°C). A dissecting microscope equipped with an ocular micrometer was used for measurement and illustration of fish. Measurements <5 mm were accurate to ±0.1 mm, and larger characters to ±0.2 mm. Several specimens were cleared to determine vertebra number. Fish used in this study are stored at the Royal Ontario Museum, Toronto, Ontario.

In general, terms used to describe fishes follow Trautman (1981). Base length of median fins is defined as the distance from the anterior margin of the first spine or soft ray to the posterior margin at the base of the last spine or ray. Snout length is the distance from the anterior margin of the premaxillary to the anterior margin of the eye. Interorbital width is the least distance between orbits. Body depth factor (BDF) and caudal depth factor (CDF) indicate general body form and swimming ability (Webb and Weihs 1986). Body depth factor is defined as mean TL/mean body depth, whereas CDF = mean caudal peduncle depth/ mean body depth. A high BDF and CDF denotes an elongate species whose depth is more or less the same along its length; e.g., clupeid or osmerid. Low values are found in centrarchids, where manoeuvrability is enhanced by a deep body and large pectoral fins. Fish volume, determined in each size class = mean total length × (mean body depth)^2.

Results

Reproductive and nursery habitat

Environmental conditions for fish reproduction and rearing differed in Duck Creek and the St. Clair River according to water quality and physical characteristics. On most dates, water temperature at the shore of the river was about 3°C lower and suspended particulate load always lower, than in Duck Creek. Whether collected at 4° or 30°C, Round Gobies were recorded in the same habitat from April to November. However, their occurrence was contingent on availability of cover. For example, gobies were not found at LGS in May 1999 when low water level completely exposed rock and rubble habitat. Recently hatched fish were rarely found along featureless, sandy shores, where

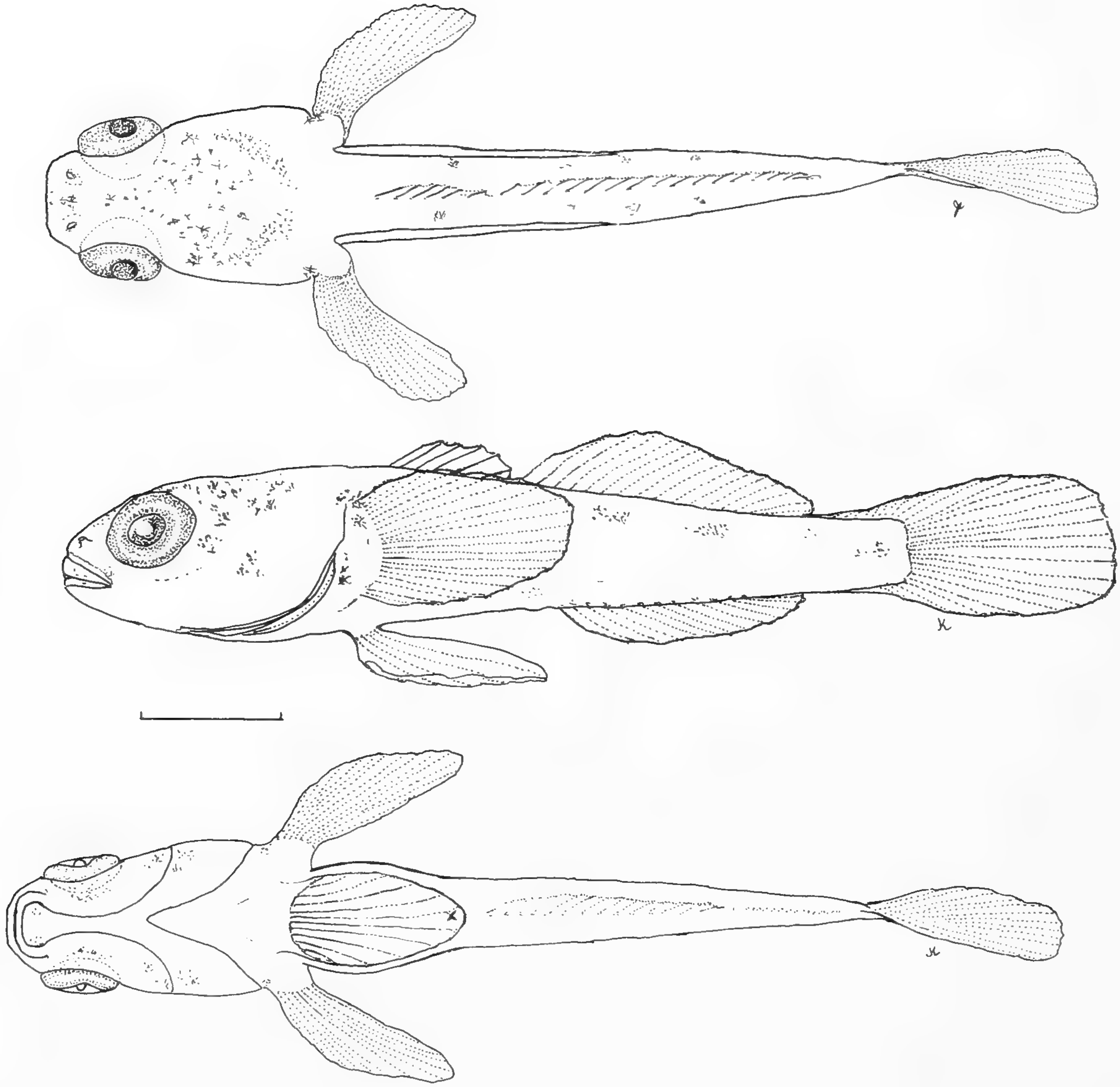

FIGURE 2. *Neogobius melanostomus* at 7.5 mm; upper: dorsal, middle: lateral, lower: ventral view. Length bar = 1 mm.

juvenile and adult gobies were occasionally caught. Small boat launches with corrugated concrete ramps were consistent sources of larger (>30 mm) specimens of age-0 gobies.

Presence of small age-0 fish in late spring and early autumn indicates a possible prolonged spawning period in Duck Creek, accommodated by water temperature >10°C from early May to mid-October. Earliest evidence of recently hatched fish (5-13 mm TL) on 1 June 1995 suggests spawning takes place in April or May. However, in early May 1998, ten gobies (22-28 mm) were caught near LGS at 10°C above ambient (4°C). These fish may have hatched in late winter in dilute heated power plant effluent. Since small gobies (14-23 mm) were found each year in September, spawning at LGS may extend to late summer.

In Duck Creek, Round Gobies endure continuous turbid water, enriched conditions, occasional dense blooms of blue-green algae (*Anabeana* sp; Cyanophyta) and temperature at least 30°C. According to size in autumn, gobies attain a mean length of about 33-39 mm at the end of first year growth. For example, in Duck Creek fish were 32.8 mm (28-36 mm) in early October 1995, whereas at LGS, they were 37.6 mm (range 31-49 mm) in November 1994 and 39.4 mm (30-45 mm) in November 1995.

Reproduction

In mid-July 1999, numerous clusters of eggs were found attached to the underside of rocks at a depth of 0.3 m in Duck Creek. A sample (N = 121) of eggs in a cluster of roughly 200 on a rectangular patch of about 30 cm^2 averaged 3.0 mm long and 1.8 mm wide with

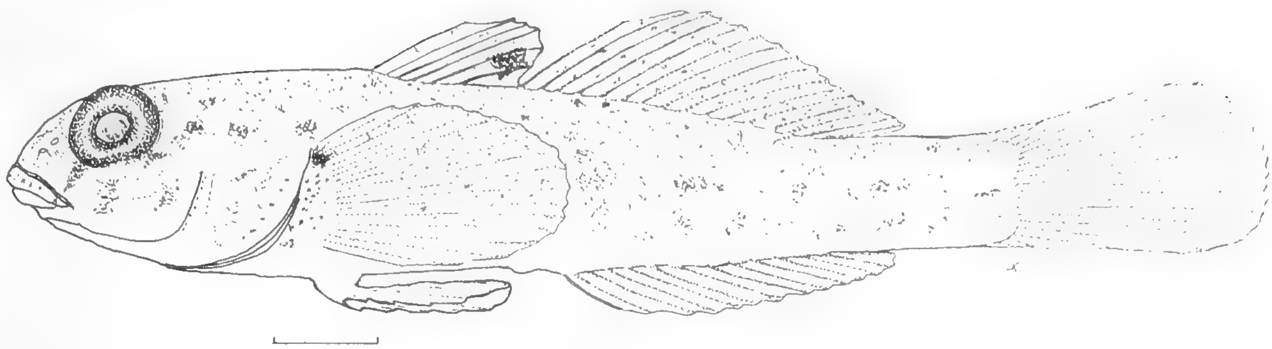

FIGURE 3. *Neogobius melanostomus* at 25 mm. Length bar = 2 mm.

respective modal values of 3.1 mm and 1.8 mm (range: 2.6-3.3 mm and 1.6-2.0 mm). Eggs are oblong with rounded base and blunt apex, with a fibre-like basal pedestal or stalk 0.4-0.5 mm long. Yolk is light orange and occupies nearly 75% of the capsule. These eggs incubated in situ in turbid, almost lentic water at 28-30°C. Similarly, egg clusters were found in early June 2000 at 14°C in the St. Clair River beneath limestone rocks and human artefacts. A cluster of approximately 300 eggs formed an oval patch (estimated area = 40 cm^2) under a rock at a depth of 0.2-0.3 m in slow flowing water. Eggs (n = 78) were 3.5 mm long and 2.0 mm wide (modal values, 3.7 mm and 2.1 mm).

Morphology

Yolk, which is usually retained in the gut of fish 4.5 to 6.5 mm long, may persist to 11 mm. At 5-8 mm, minute teeth are present on the jaws. Origin of D1 is at the fourth myomere or fifth vertebra, whereas D2 originates at the seventh or eighth myomere (eleventh or twelfth vertebra). Scales first appear on mid-caudal peduncle at approximately 8-9 mm and body scalation may be complete at 12-15 mm.

The upper lip is protractile and jaw articulation is below the anterior margin of the pupil. The anterior tubular nostril protrudes, whilst the minute posterior nostril is flush. At about 13 mm the cranium is depressed, cheeks begin to enlarge, and sub-orbital canals and papillae are barely visible. At all sizes, the head is bluntly arrow-shaped in ventral profile (Figure 2). All spines and fin rays are formed, although principal rays are incomplete in the caudal fin. Pectoral fin rays are joined distally by membrane. A small genital papilla is first obvious at about 23 mm.

Origin of D2 is on a vertical line with the anus and separated from D1 by a flap of tissue. Full complement of branched caudal rays is attained at about 20 mm. At 22-25 mm, the pectoral fins are slightly flared ventrally and depressed D2 and anal fins extend equally to mid-peduncle (Figure 3). Two short, stout spines support a transverse membrane on the pelvic fin, the whole forming a suctorial disc.

Fish >30 mm have a moderately rounded snout and large protruding dorsolateral eyes above bulging cheeks. Sub-orbital papillae occur in transverse rows (Figure 4). The tip of the large fleshy upper lip is anterior to the lower, and the opening of the terminal mouth lies below the ventral margin of the eye. The centre of the pupil lies along a horizontal line with the origin of the pectoral fin. Gill openings are narrow. Ctenoid scales cover the body, whereas cycloid scales occupy the anterior nape and gill covers. In outline,

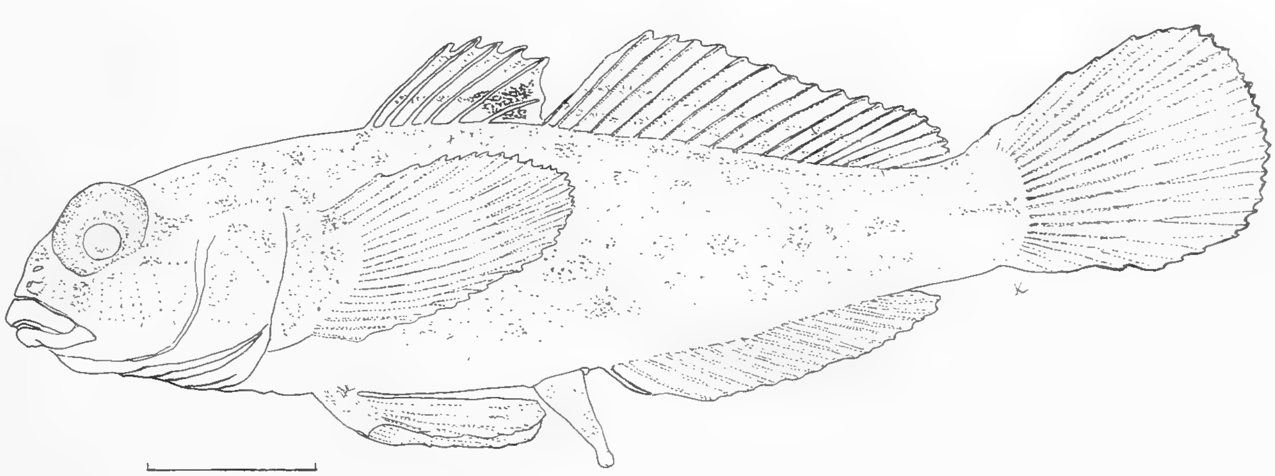

FIGURE 4. Lateral view of male *Neogobius melanostomus* at 38 mm. Length bar = 5 mm.

TABLE 1. Morphometrics for age 0 *Neogobius melanostomus* collected in the St. Clair ecosystem, Ontario. Lengths are percentage (with range) of mean total length (TL) in each size class.

Size class	5.0-8.9 n = 20	9.0-12.9 n = 9	13.0-16.9 n = 2	17.0-20.9 n = 9	21.0-24.9 n = 21	25.0-32.9 n = 33	33.0-39.9 n = 23
Mean TL	7.3 ± 1.2	10.4 ± 1.2	13.3 ± 0.1	18.5 ± 0.9	23.5 ± 0.9	28.7 ± 2.1	35.3 ± 1.8
Standard	79.0	79.3	78.1	80.3	79.8	79.5	80.3
	73-86	78-83	77-79	79-83	78-83	77-81	79-82
Preanal	45.8	43.8	41.5	44.0	44.7	44.0	43.4
	43-52	42-45	41-42	43-46	41-48	42-51	39-46
Predorsal	33.0	31.2	30.6	30.1	29.7	29.2	28.2
	30-42	30-33	30-32	29-32	28-32	27-31	24-29
Prepelvic	25.1	27.1	27.6	27.1	27.0	26.6	26.6
	18-30	24-31	27-28	26-28	24-32	25-29	25-34
Body depth	17.8	16.8	15.5	17.5	16.9	17.6	17.7
	14-21	15-18	14-17	14-20	15-19	15-20	16-19
Peduncle	7.5	8.0	8.3	9.0	8.9	8.9	8.8
	6-9	7-9	0	9-10	8-9	9-10	8-10
Head	26.2	26.3	27.6	25.5	25.3	24.8	24.0
	21-30	24-29	27-28	25-27	24-27	23-27	23-26
Eye[a]	30.6	31.1	27.6	33.0	32.4	32.2	30.3
	25-37	26-35	27-28	31-35	28-35	28-35	26-35
Volume (mm^3)	12.3	30.1	55.7	189	357	732	1401
BDF	5.6	6.1	6.5	5.8	6.0	5.7	5.6
CDF	0.42	0.49	0.54	0.53	0.52	0.51	0.50
Pectoral fin	18.6	19.7	21.5	23.6	24.0	23.5	23.6
	10-22	17-22	21-22	22-25	22-25	19-27	21-26
Pelvic fin	15.5	17.2	19.3	21.3	19.9	20.1	19.8
	9-21	13-19	18-20	20-22	18-21	18-22	17-23
Dorsal 1 base	7.0	7.8	6.5	8.8	8.5	9.0	9.2
	5-11	6-10	6-7	8-9	7-12	8-11	7-11
Dorsal 2 base	24.3	23.5	23.4	25.2	24.7	25.9	25.5
	19-30	20-29	23-24	24-28	20-29	24-27	24-27
Anal base	20.5	19.7	18.5	19.6	19.2	20.6	20.4
	18-24	16-23	17-20	17-22	17-22	17-23	19-23

[a] % head length

D1 is slightly rounded, D2 slopes slightly, and the anal fin is uniform (Figure 4).

Morphometry

Relative changes in lengths are generally small as fish grow (Table 1). Head length (24-28% TL) is 1.3 times its width and 1.4 times its depth. Snout length increased from 15% HL at 7 mm to 20% HL at 35 mm. Interorbital width, variable among and within size classes, is 10-22% HL. Pectoral fin rays are 19-24% TL whereas D2 base is 23-26% TL. Longest spines and base of D1 are about equal but less than the longest ray of D2. On fish >35 mm, the pectoral fin base is approximately 55% greatest body depth. Body depth and caudal depth factors are generally constant (Table 1).

Meristics

Respective modal counts for preanal, postanal, and total myomeres are 12 (range, 11-13), 19 (17-20), and 31 (29-32). Modal spine and fin ray complements are D1: VI, D2: I 15 (13-16), anal: I 13 (11-13), pectoral: 18 (16-19), pelvic(s): I 5 (conjoined), principal caudal: 13 (11-13). There are 33 modal (32-33) vertebrae and 49 (48-52) ctenoid scales in mid-lateral series.

Pigmentation

On free embryos, pigmentation consists of black eyes and several black spots on posterior spines of D1. However, on many specimens <9 mm, the characteristic black spot on D1 is absent. Speckled melanophores on snout and dorsum of head, a dark crescent on the occiput and a small patch on the cheek are typical at 10-12 mm. Ventrally, an elongate stellate melanophore is situated mid-gut. About five faint dorsolateral clusters are expressed on the body. There is a small group of stellate melanophores on frontal and parietal areas, a ventral patch on the pectoral fin base and a subcutaneous series on the intestine. Melanophores develop at the base of each anal fin ray, and a narrow mid-ventral series prevails from anal fin base to caudal fin base (Figure 2). At 14 mm, striation extends from maxilla to orbit and a black spot is pronounced between fifth and sixth spines on D1. Several faint mid-lateral blotches extend the length of the body.

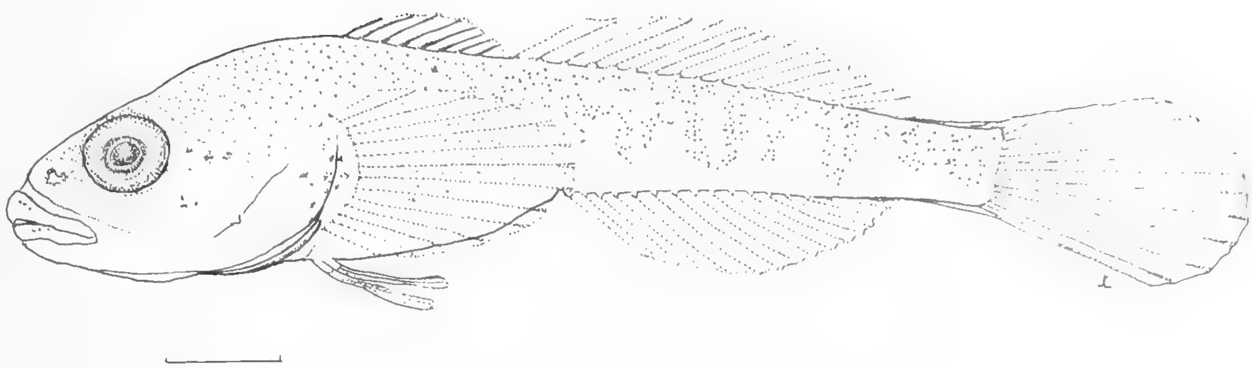

FIGURE 5. *Cottus bairdi* at 10.5 mm. Length bar = 1 mm.

At 22-25 mm a large brown patch is obvious on the dorsal peduncle of the pectoral fin. First four rays of D1 are lightly pigmented, and patches appear on the base of interradials. A faint stripe exists mid-fin on D1 (Figure 3). Posterior margins of body scales are darkly outlined and rays at the base of the caudal fin are lightly pigmented. A small basicaudal spot persists throughout development.

Fish >30 mm have a small stripe on the preopercle, and about seven irregular patches of brown pigment on the side of the body, mainly below the mid-line. Otherwise, lips and dorsum of head are covered with small round spots, whilst the throat is essentially devoid of pigment. Pelvic and caudal fins are lightly spotted, whereas D2 has two pale longitudinal stripes. Pigmentation patterns are intensified over head, body, and fins (Figure 4). Overall colouration on individuals varies from dark brown to grey-brown.

Description of age-0 Mottled Sculpin

Mottled Sculpin larvae (11.4 ± 1.1 mm; n = 5) have the following characters: preanal length 41% TL, head 25%, eye 29% head length; head length and width equal; predorsal length 29% TL, prepelvic length 24%. Branchiostegals 3,4. Except for pelvic fin separation, overall body characters are similar to gobies (Figure 5). Pigmentation features black eyes and approximately six lateral saddle marks on the body. Melanophores are absent on the ventral body surface and fins. Meristics for this, and superficially similar, species are given in Table 2.

Discussion

The Round Goby is an eurythermal fish adapted to slightly brackish environments in the Caspian and Black seas (Miller 1986). In the Great Lakes basin it is ubiquitous in the littoral zone, including ecotones intolerable to many of our native fishes. Eggs incubate in almost static water in Duck Creek, a stream burdened with silt, and at times, blooms of blue-green algae at high temperatures. Concurrently, eggs may develop in the St. Clair River in water of high quality and clarity at temperatures several degrees lower than in small turbid streams in the same catchment. The reproductive strategy includes parental guarding of eggs and free embryos. In the St. Clair aquatic ecosystem, age-0 Round Gobies appear to remain natal stream and shore habitats throughout their first year of growth. Solid objects, unlike sand and other unstable substrates, provide surfaces essential for attachment and refuge for small gobies in flowing water.

Reproduction is prolonged and extensive but varies geographically. In their native range, gobies migrate to spawning habitat at 9-26°C and reproduce from April-September in intervals of 3 or 4 weeks (Charlebois et al. 1997). Similar data for the Great Lakes are lacking, although MacInnis and Corkum (2000) suggest a possible spawning period from April to November in the upper Detroit River. In power plant cooling water discharges, the reproductive period may extend from winter to late summer or beyond, since the endocrine system is active all year (Charlebois et al. 1997) and water temperatures are constantly >10°C.

TABLE 2. Comparison of meristics of several Great Lakes age-0 fishes superficially similar in appearance.

Species	D1 fin	D2 fin	Pelvic fin	Pectoral fin	Anal fin	Preanal myomeres	Postanal myomeres	References
Etheostoma exile	VIII-X	10-12	I, 5	12-14	II, 7-8			Heufelder 1982
Etheostoma nigrum	VIII-XI	10-14	I, 5	11-12	I, 7-10	15	21	Heufelder 1982
Etheostoma caeruleum	X	12	6	13	II, 7	16-17	18-19	Cooper 1979
Cottus bairdi	VII-IX	16-19	I, 3-4	13-17	13-14	9-12	19-21	Heufelder 1982
	VII-VIII	15-17	I, 3-4	13-15	13	9-10	19-21	This study
Cottus cognatus	VII-IX	16-19	I, 3-4	12-16	10-14	9-12	19	Heufelder 1982
Proterorhinus marmoratus	VI-VII	16-19	I, 5	14-15	I, 13	11	20	Leslie et al. 2002
Neogobius melanostomus	VI	13-16	I, 5	18	I, 13	12	19	This study

In the study area, batches of about 200-300 eggs represent an absolute fecundity of 800-1200, assuming four spawning episodes. MacInnis and Corkum (2000) estimated an absolute fecundity of 252-1818 eggs based on three spawning episodes from late May to the end of July in the upper Detroit River. Miller (1986) reported fecundity of gobies 7-13 cm long as 328-5221 in the Black-Caspian-Azov seas, whilst Kuczyñski (1995) calculated 2700-3000 eggs in the Gulf of Gdansk. In general, fecundity is lower and eggs slightly smaller (3.7-3.9 mm long, 2.0-2.2 mm wide) than in the Black and Baltic seas, possibly because the spawning population is younger and fish are smaller (MacInnis and Corkum 2000).

Moskal'kova (1967) reared embryos that emerged from the egg at 5.5-5.7 mm and remained in the nest 4-9 days. Gobies do not have a true larval stage (Miller 1986) and hatch with most characteristics of juveniles. However, in the present study, smallest gobies (4.5-5.0 mm) feature a large yolk sac and incomplete complement of fin rays. These fish may have extruded from eggs during the collection process and perhaps are not representative of free embryos. Otherwise, smallest specimens found in coarse gravel were clearly unguarded, free-living fish.

The Round Goby is a cryptic, benthic fish, devoid of air bladder and planktonic stage. As such, early developmental stages are found in and among firm structures. Gobies have smaller caudal and body depth factors than larvae capable of high thrust and acceleration, such as Anchovy (Eugraulidae), Alewife (Clupeidae) or percids (C. A. Timmins, unpublished, 2000). The Round Goby may not be a strong or fast swimmer, but its large head, robust body, and large pectoral fins enhance its manoeuvrability.

Age-0 Round and Tubenose gobies did not co-occur in any given habitat in the St. Clair ecosystem, although they partitioned habitat in a small area near the mouth of Duck Creek (Leslie and Timmins 1998). Usually, small age-0 Round and Tubenose gobies may be separated on the basis of head and body pigmentation, which is much lighter in the former. Whereas the Round Goby has a conspicuous black spot on the posterior spines of D1, the Tubenose Goby has an oblique stripe on anterior spines. Further, tubular nostrils that extend beyond the upper lip are peculiar to the Tubenose Goby. However, most mensural characters overlap for these gobies. Thus, small (<6 mm) unpigmented fish may not be separable.

Fishes with similar habitat requirements and morphology, such as cottids, darters, and gobies sometimes co-occur. Recently hatched Mottled Sculpins are precocious and appear similar to gobies (Figure 5). However, all fins are developed in recently hatched Round Gobies, whereas cottids (and darters) have a complete fin fold and separate pelvic fins, which are expressed some weeks post-hatch. In addition, preanal and total myomere counts of cottids and darters do not overlap with those of gobies. Fin spine and ray counts and pigmentation patterns also differ among these taxa.

The Round Goby has survival advantage over many competitors. It reproduces repeatedly from spring to autumn, the critical life stage is not determined by specific seasonal type or quantity of food, its embryos hatch with almost all external structures elaborated, the young are guarded in nests and it persists in natal habitats. Certainly, few native fishes of the Great Lakes basin are as morphologically and physiologically suited to thrive in comparable environmental conditions. Therefore, geographic range expansion and proliferation of the species seems likely in the Great Lakes Basin.

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A Systematic Analysis of the Alpine Saxifrage Complex (Saxifragaceae) in the Canadian Arctic Islands Using Morphology and Chloroplast DNA Data

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Healy, Caroline, and Lynn J. Gillespie. 2004. A systematic analysis of the alpine saxifrage complex (Saxifragaceae) in the Canadian Arctic Islands using morphology and chloroplast DNA data. Canadian Field Naturalist 118(3): 326-340.

The *Saxifraga nivalis* complex displays significant ecological, morphological and cytological variation. Most European studies suggest that the *S. nivalis* complex comprises two distinct species: *Saxifraga nivalis* sensu stricto and *Saxifraga tenuis*. However, the presence of intermediate morphotypes, inconsistencies in chromosomal counts and variability in morphological keys and descriptions have led to different taxonomic interpretations of the complex in North America. This study investigated the systematics of Canadian Arctic Island members of this complex from 157 specimens using 23 morphological characters. Principal component analysis of the morphological data revealed two adjacent clusters, corresponding to the two taxa and consistent with a close morphological similarity and the presence of hybrids. A preliminary restriction site analysis of five non-coding regions of the chloroplast genome, *trn*H-*trn*K, *trn*T-*trn*F, *trn*F-*trn*V, *trn*V-*rbc*L and *rbc*L-ORF106, was conducted using 21 restriction endonucleases. This analysis indicated a length difference between the *trn*T-*trn*F region of *S. nivalis* and that of *S. tenuis*, but no difference in restriction sites for any of the assayed regions. These results confirm that in the Canadian Arctic, the *S. nivalis* complex consists of two closely related, largely sympatric species, with notable morphological variability, and possible hybrids.

Key Words: Alpine Saxifrage, *Saxifraga nivalis*, *Saxifraga tenuis*, Canadian Arctic, systematics, morphology, chloroplast DNA restriction site analysis.

Saxifraga L., the largest genus in the Saxifragaceae, consists of nearly 400 herbaceous, mostly perennial species (Webb 1993; Soltis et al. 1993, 1996). *Saxifraga nivalis* L. sensu lato, commonly known as the Alpine Saxifrage, inhabits arctic and alpine environments throughout the northern hemisphere. The *S. nivalis* complex is dispersed throughout northern and alpine Europe, Siberia, arctic and subarctic North America and south in the alpine zone to Arizona and the Gaspé, Quebec (Britton and Brown 1913; Krause and Beamish 1973; Scoggan 1978; Webb 1993). Members of the *S. nivalis* complex display notable morphological, cytological and ecological variation, which has led to different taxonomic interpretations and classifications.

Linnaeus (1753) first described *S. nivalis*, a name that means snow saxifrage, as these plants are often found growing in snow patch plant communities (Britton and Brown 1913). Later, Wahlenberg (1812) recognized *S. nivalis* var. *tenuis* Wahlenb. for plants with a notably smaller stature, fewer flowers, smaller fruits and recurved stigmas. Smith (in Lindman 1918) elevated Wahlenberg's variety to *Saxifraga tenuis* (Wahlenb.) Harry Sm. However, the taxonomy of the *S. nivalis* complex remained problematic and the acceptance of *S. tenuis* as a species was controversial. For instance, Böcher (1938) recognized *S. nivalis* and *S. tenuis* as distinct species, but also suspected the presence of races and microspecies within the *S. nivalis* complex. Polunin (1940) found the two taxa difficult to separate morphologically with intermediates and suggested the need for breeding and cytological studies before distinguishing them at the species level. Although accepted as a distinct species in Scandinavia and Greenland, based on samples from Alaska and the Yukon, Hultén (1945) concurred at the time with Polunin in treating the taxon as *S. nivalis* var. *tenuis* because of its minimal phenotypic distinction from *S. nivalis* and its low frequency of occurrence within the area of distribution of *S. nivalis*. However, in the Canadian Arctic, Porsild (1957, 1964) and Porsild and Cody (1980) recognized *S. nivalis* and *S. tenuis* as distinct species. Upon further examination of specimens from Alaska and neighboring regions, Hultén (1968) also recognized the two taxa at the species level. More recently Scoggan (1978) and Aiken et al. (1998) treat the two taxa as varieties of *S. nivalis*.

Taxonomic and nomenclatural ambiguity also stemmed from the description of additional varieties and microspecies, as well as the re-emergence of Haworth's (1812) suggestion to revise Linnaeus' concept of the genus *Saxifraga* (reviewed in Spongberg 1972). In 1905, Small divided the genus *Saxifraga* into 13 genera in North America (in Small and Rydberg 1905; reviewed in Soltis et al. 1996). Small treated *S. nivalis* as *Micranthes nivalis* (L.) Small, *S. nivalis* var. *tenuis* as *Micranthes tenuis* (Wahlenb.) Small, and distinguished an additional species in the Canadian eastern Arctic, *Micranthes kumlienii* Small. However, subsequent authors did not recognize the genus *Micranthes*,

and *M. kumlienii* was treated as belonging to *S. nivalis* (Polunin 1940; Aiken et al. 2000*). Fernald (1917) distinguished *Saxifraga nivalis* var. *labradorica* Fern., a variety localized in Labrador, and suggested that this plant corresponded to Small's concept of *Micranthes tenuis*. Subsequently, this variety was treated as a synonym of *S. nivalis* var. *tenuis* (Scoggan 1978) or as a luxuriant form of the latter (Polunin 1940). In the Gaspé Peninsula, Fernald (1917, 1950) identified another member of the *S. nivalis* complex, *Saxifraga gaspensis* Fern. Subsequently, this species was included under *S. nivalis* var. *tenuis* (Scoggan 1950, 1978), treated as *S. nivalis* var. *gaspensis* (Fern.) Boivin (Boivin 1966), and then considered as small *S. nivalis* s.s. (Blondeau 1989a). Most recently, Gervais et al. (1995) followed Fernald in treating the Gaspé population as a distinct species. In Alaska, Hultén (1968) considered *S. nivalis* as highly variable, recognizing *S. nivalis* var. *tenuis*, and describing *S. nivalis* var. *rufopilosa* Hultén for plants characterized by "densely pubescent, rufous-haired leaves and red petals" (page 579) found in Alaska and the Yukon. Porsild (1957, map page 188) appeared to treat *S. rufopilosa* under *S. tenuis* according to his map of that species (see also Porsild and Cody 1980, map page 403; Cody 1996). Later, Porsild (1975) recognized the latter as the distinct species, *S. rufopilosa* (Hult.) A. E. Porsild, and suggested that it was more closely related to *S. tenuis* than *S. nivalis*. Cody (1996) also recognized *S. rufopilosa* as a distinct species and considered *S. tenuis* as not present in the Yukon. In 1978, Scoggan's concept of *S. nivalis* var. *tenuis* encompassed *S. tenuis, S. gaspensis*, *S. nivalis* var. *labradorica* and *S. nivalis* var. *rufopilosa.*

Based on cytology and morphology, Löve (1983) and Webb (1964, 1993) discerned the species *S. nivalis* (2n = 60) and *S. tenuis* (2n = 20) in Europe. The taxonomic ambiguity regarding the *S. nivalis complex* in North America (Aiken et al. 2000*) appears to stem from the following factors: (1) several morphological characters used to distinguish the species in Europe do not hold up in North America; (2) taxa can be found growing together; and (3) intermediate morphotypes, as well as variation in chromosomal counts suggest hybridization. Various cytological studies of material from North America have demonstrated cytological diversity within the *S. nivalis* complex with chromosomal counts of 2n = 20, 40, c. 56, 58, 60 or c. 60. While most support the above European counts for *S. nivalis* and *S. tenuis* (Mosquin and Hayley 1966; Hedberg 1967; Johnson and Packer 1968; Packer and McPherson 1974; Löve and Löve 1975), several studies found intermediate chromosome counts. Krause and Beamish (1973) provide counts for plants of the *S. nivalis-tenuis* complex from the Yukon (2n = 20, 40), British Columbia (60) and Idaho (20), which they were unable to identify to species. Intermediate chromosome counts have also been found in the Russian Arctic in a plant described as *S. nivalis* × *S. tenuis* (Devyatov et al. 1997). In the Gaspé Peninsula *S. gaspensis* is considered to be a putative endemic hybrid based on chromosome number (2n = 40) and apparent intermediate morphology (Gervais et al. 1995). Further confusion results from the variance and discrepancies among the morphological keys used in the identification of this complex and related species, such as *S. foliolosa* R. Br., which are occasionally misidentified as members of the *S. nivalis complex*. Consequently, accurate and consistent identification of North American plants belonging to this complex can be problematic.

The aim of this study was to investigate the distinctiveness of *S. nivalis* and *S. tenuis* in the Canadian Arctic Islands based on morphological and molecular differences, and to help reassess the taxonomic status of *S. tenuis*.

Material and Methods

Morphological Analysis

Specimens

Representative specimens from the Canadian Arctic were selected from the Canadian National Herbarium, Canadian Museum of Nature (CAN), and the Agriculture and Agri-foods Canada Herbarium, Central Experimental Farm, Ottawa (DAO). Morphological data were gathered from observations and measurements on 157 herbarium sheets (listed in Appendix I), including two chromosome count vouchers (*S. nivalis*, 2n = 60, *Calder et al.* DAO 24148; *S. tenuis,* 2n = 20, *Calder et al.* DAO 24149). One plant per sheet was sampled, except when sheets comprised mixed collections or included DNA vouchers, and then multiple plants per sheet were sampled. A total of 200 plants were sampled, 122 *S. nivalis* and 78 *S. tenuis*. More specimens of *S. nivalis* were available for study than of *S. tenuis*. Where identifications of examined specimens were judged questionable, specimens were re-identified based on a combination of published keys and preliminary results. Additionally, identifications of many *S. tenuis* specimens at CAN were subsequently confirmed for the Panarctic Flora Project (E. Reidar, 2001, 2002).

Morphological characters

Characters used in descriptions and keys of the *S. nivalis* complex (Simmons 1906; Polunin 1940; Porsild 1957; Löve 1983; Blondeau 1989a, 1989b; Webb 1993; Aiken et al. 1998, 2000*) were reduced to a set of 30 characters based on ease of observation or measurement on dried specimens as well as their taxonomic significance. Of these, 23 were selected for statistical analysis (Table 1). Petal length was excluded from all analyses due to difficulties in measuring petals that were often folded and partly included within the calyx. The qualitative characters, stem colour, petal shape, prominence of leafy bract on stem, leaf blade shape, leaf blade base shape and apex shape, were excluded due to variation within a plant or difficulties in determining discrete states.

TABLE 1. Morphological characters used in analyses of the *Saxifraga nivalis* complex in the Canadian Arctic.

Quantitative characters:

1. Plant height (cm): HEIGHT; length from basal rosette to top of inflorescence
2. Stem width (mm): STWIDTH; measured midway along lower half of stem
3. Stem hair density (0, glabrous to 4, dense): STHRDENSITY
4. Stem hair length (mm): STHRLENGTH; measured midway along lower half of stem.
5. Leaf blade length (cm): LFLENGTH; measurement made on the largest leaf
6. Leaf blade width (cm): LFWIDTH; measurement made on the largest leaf
7. Hair length on leaf lower surface (mm): UNDHRLGTH
8. Hair length along leaf margin (mm): MRGHRLGTH
9. Number of teeth on leaf: TEETH; count made on the largest leaf
10. Tooth width (mm): TTHWIDTH; measurement made on largest tooth on the largest leaf
11. Tooth length (mm): TTHLENGTH; measurement made on largest tooth on the largest leaf
12. Petal width (mm): PTWIDTH; measurement made on the largest petal

Qualitative characters:

1. Stem hair colour (rust-coloured; mixed rust and white; white)
2. Stem hair texture (short fine; long coarse)
3. Tooth apex shape (rounded; pointed)
4. Regularity of teeth (even in size; variable in size smaller towards leaf blade apex)
5. Hair presence on leaf lower surface (moderate to dense; sparse; absent)
6. Hair colour on leaf lower surface (rust; white)
7. Hair presence on leaf margin (moderate to dense; sparse; absent)
8. Hair colour on leaf margin (rust; white)
9. Inflorescence density (open; tight cluster)
10. Style shape (curved; straight or essentially so)
11. Petal colour (pink or essentially so; white or essentially so)

The software package DELTA (Dallwitz et al. 1993) and the character set for the "Flora of the Canadian Arctic Archipelago" (Aiken et al. 2002*) were used to generate preliminary taxon descriptions. These descriptions were then modified to read more easily, to exclude irrelevant characters, and to include important diagnostic characters not included in the Flora character set.

Statistical analysis

All statistical analyses were performed with SYSTAT version 8.0. For each quantitative trait, the means for *S. tenuis* and *S. nivalis* specimens were compared by performing t-tests. Separate variance values were calculated for each taxon. T-tests were conducted on both raw and log-transformed data. A principal component analysis (PCA) using the 12 quantitative characters indicated in Table 1 was conducted to visualize possible distinctiveness between *S. nivalis* and *S. tenuis*. The character MRGHLGTH was excluded from some PCA analyses due to a large amount of missing data in *S. tenuis*, which sometimes lacked marginal hairs. The PCA analysis excluded all specimens with missing values. A discriminant function analysis was also performed on the quantitative data. For the 11 selected qualitative characters (Table 1) the percentages of specimens having each character state was determined for each taxon.

To determine if there was any geographical pattern to the morphological variation in *S. tenuis*, principal component analysis was performed only on the *S. tenuis* quantitative data (excluding MRGHLGTH). This analysis also included five specimens from Alaska (*Calder 6107, 6511, 6249* DAO) and northern British Colombia (*Calder & Kukkonen 28151* DAO, *Taylor et al. 1204* DAO) not included in the larger analysis. Individuals were coded as occurring in one of three regions: high arctic (67), eastern arctic (11) or western montane (5).

Chloroplast DNA analysis

Plant material and DNA extraction

A total of 15 plants, for which silica gel dried material was available, were selected for molecular analysis: seven individuals of *S. nivalis* (*Gillespie 6165, 6675-1, 6826a-1, 6826a-2, 6977-2, 6984-5*; *Aiken 98-055-3*), seven *S. tenuis* (*Gillespie 6728-1, 6807-1, 6807-3, 6825-2, 6870-2, 6877-1, 6881-3*), and one *S. foliolosa* (*Gillespie 6841*) (Appendix 1). The latter species was selected to provide perspective on the chloroplast DNA (cpDNA) data, based on its close phylogenetic relationship to the *S. nivalis* complex (Soltis et al. 1996). DNA was extracted following Doyle and Doyle's (1990) CTAB total DNA extraction procedure as modified by Gillespie et al. (1997).

Restriction site analysis

DNA extracts were PCR amplified using five pairs of universal primers for non-coding regions of chloroplast DNA. The five regions are: *trn*H-*trn*K (Demesure et al. 1995), *trn*T-*trn*F (Taberlet et al. 1991), *trn*F-*trn*V (Dumoulin-Lapegue et al. 1997), *trn*V-*rbc*L (Dumoulin-Lapegue et al. 1997), and *rbc*L-ORF106 (Arnold et al. 1991). Amplification reaction mix and programs follow Gillespie and Boles (2001).

TABLE 2. Descriptive statistics and t-test comparing the means of *S. nivalis* and *S. tenuis* at the 95% confidence level for 12 quantitative morphological characters.

Character	Taxon	N	Mean (±SD)	Range Min	Range Max	Difference in means	t value	df	p
Plant height (cm)	*S. nivalis*	122	9.12 (±3.37)	1.7	18.0	4.66	13.68	176.2	0.000
	S. tenuis	78	4.40 (±1.40)	1.8	8.5				
Stem width (mm)	*S. nivalis*	122	1.37 (±0.35)	0.7	2.5	0.82	23.06	178.6	0.000
	S. tenuis	78	0.56 (±0.15)	0.3	1.0				
Stem hair density	*S. nivalis*	122	3.2 (± 0.70)	1	4	2.0	24.94	205.0	0.000
	S. tenuis	78	1.2 (± 0.36)	1	3				
Stem hair length (mm)	*S. nivalis*	122	3.2 (± 0.70)	1	4	0.67	35.45	188.5	0.000
	S. tenuis	77	0.19 (±0.09)	0.1	0.5				
Leaf blade width (cm)	*S. nivalis*	119	0.96 (±0.34)	0.4	2.1	0.51	14.81	161.2	0.000
	S. tenuis	77	0.44 (±0.13)	0.2	0.8				
Leaf blade length (cm)	*S. nivalis*	119	1.38 (± 0.50)	0.6	3.6	0.69	13.51	166.5	0.000
	S. tenuis	77	0.67 (± 0.18)	0.4	1.5				
Hair length on lower leaf surface (mm)	*S. nivalis*	120	0.38 (±0.13)	0.2	1.2	0.10	7.25	197.0	0.000
	S. tenuis	78	0.27 (±0.06)	0.1	0.5				
Hair length on leaf margin (mm)	*S. nivalis*	121	0.19 (± 0.07)	0.1	0.4	0.07	8.47	167.4	0.000
	S. tenuis	55*	0.12 (± 0.04)	0.1	0.2				
Number of teeth on leaf blade	*S. nivalis*	118	10.3 (±1.74)	7	14	2.8	16.63	167.8	0.000
	S. tenuis	78	7.5 (±0.73)	6	9				
Tooth width (mm)	*S. nivalis*	118	1.17 (± 0.42)	0.5	3.5	0.37	7.86	195.6	0.000
	S. tenuis	78	0.80 (± 0.24)	0.5	1.6				
Tooth length (mm)	*S. nivalis*	118	1.52 (±0.48)	0.8	3.2	0.62	11.84	190.5	0.000
	S. tenuis	78	0.90 (±0.26)	0.4	1.8				
Petal width (mm)	*S. nivalis*	120	1.12 (±0.24)	0.7	1.8	0.40	14.16	202.0	0.000
	S. tenuis	77	0.72 (±0.16)	0.5	1.1				

* Marginal hair was not present in all *S. tenuis*

PCR products were single digested with twenty one restriction endonucleases according to manufacturer's recommendations. These included nine 4-base pair (bp) cutting restriction enzymes: *Alu*I, *Hae*III, *Hha*I, *Msp*I, *Rsa*I, *Dde*I, *Hinf*I, *Sau*96I, *Taq*I; two 5bp cutting restriction enzymes: *Bst*OI, *Sin*I; and ten 6bp enzymes: *Apa*I, *Bam*HI, *Bgl*I, *Bgl*II, *Dra*I, *Eco*RI, *Eco*RV, *Hinc*II, *Pst*I, *Xho*I. To separate restriction fragments, 8 μL of the reaction mixture and 2 μL of buffer-dye mix were run on 1.1% agarose gels with ethidium bromide at 38 V for 2-3hrs. The restriction fragment patterns were visualized and photographed under ultraviolet light.

TABLE 3. Distribution of qualitative morphological character states in *Saxifraga nivalis* and *S. tenuis* in the Canadian Arctic. Numbers represent percentage of individuals having a particular character state.

Character	Character state	*S. nivalis*	*S. tenuis*
Stem hair colour	rust	1.3	74.4
	mixed	0	25.6
	white	98.7	0
Stem hair texture	short fine	1.6	100
	long coarse	98.4	0
Tooth apex shape	rounded	2.5	100
	pointed	97.5	0
Regularity of teeth	even-sized	18.3	87.2
	variable	81.7	12.8
Hairs presence on leaf lower surface	moderate-dense	91.7	84.6
	sparse	7.5	15.4
	absent	0.8	0
Hair colour on leaf lower surface	rust	40.0	79.5
	white	60.0	20.5
Hair presence on leaf margin	moderate-dense	91.7	10.3
	sparse	8.3	60.3
	absent	0	29.5
Hair colour on leaf margin	rust	20.7	60.0
	white	79.3	40.0
Inflorescence density	open	1.8	97.1
	tight cluster	98.2	2.9
Style shape	curved	25.9	84.7
	straight	74.1	15.3
Petal colour	pink	14.9	81.8
	white	85.1	18.2

Lengths of total amplified product and restriction fragments were estimated by comparison with known 100 bp ladder DNA markers.

Results

Morphological Analysis

To determine whether the means of the examined quantitative characters were different between *S. nivalis* and *S. tenuis*, t-tests were performed (Table 2). The analysis revealed a significant difference in means between the two taxa for all characters examined. Overall, plants belonging to *S. nivalis* are more robust than *S. tenuis* as implied by higher means in both plant height and stem width observed in *S. nivalis*. Similarly, leaves of *S. nivalis* are on average longer, wider and have longer, wider and more numerous marginal teeth than *S. tenuis*. Also, hairs on the stems are longer and denser and hairs on the lower surface and margin of leaves are on average longer in *S. nivalis*. Petal width was significantly greater in *S. nivalis* than in *S. tenuis*. However, the two taxa have notably different variances, with *S. nivalis* having a higher variance than *S. tenuis* for all quantitative characters examined. Considering the very low probability values and the robustness of t-tests for samples of this size, the differences in means can be considered as meaningful. Analyses were also performed on log-transformed data, with no significant differences.

The frequency of occurrence of states of qualitative characters differed considerably between the two taxa for most characters (Table 3). The characters, stem hair colour and texture, tooth apex shape and inflorescence density, differed significantly between the two taxa, with less than a five percent overlap in states. Several characters, regularity of teeth, petal colour and style shape, exhibited an overlap in states of 10-26% between the two taxa. In contrast, one character, hair presence on lower leaf surface, displayed very similar frequencies of states between *S. nivalis* and *S. tenuis*, with hairs present in over 95% of the specimens examined in both taxa, although density was sometimes more sparse in *S. tenuis*. The remaining characters displayed considerable overlap in states between the taxa.

The principal component analysis of quantitative characters (excluding MRGHLGTH) revealed two clusters, positioned adjacent to each other with little overlap (Figure 1). Factor loading for the analysis was STWIDTH, LFWIDTH, LFLENGTH, STHRLENGTH, STHRDENSITY, HEIGHT, TEETH, PTWIDTH and TTHLENGTH for factor 1, and TTHWIDTH and UNDHRLGTH for factor 2, with 61% and 10% of total variance explained by factors 1 and 2, respectively. As noted above, there is considerable variation among *S. nivalis* plants for most examined characters. This can be observed on the graph through the large oblique spread of *S. nivalis* compared to *S. tenuis*. The PCA including the character MRGHLGTH produced very similar results (although displayed fewer individuals). The discriminant function analysis performed on the same data distinguished between the two taxa 100%

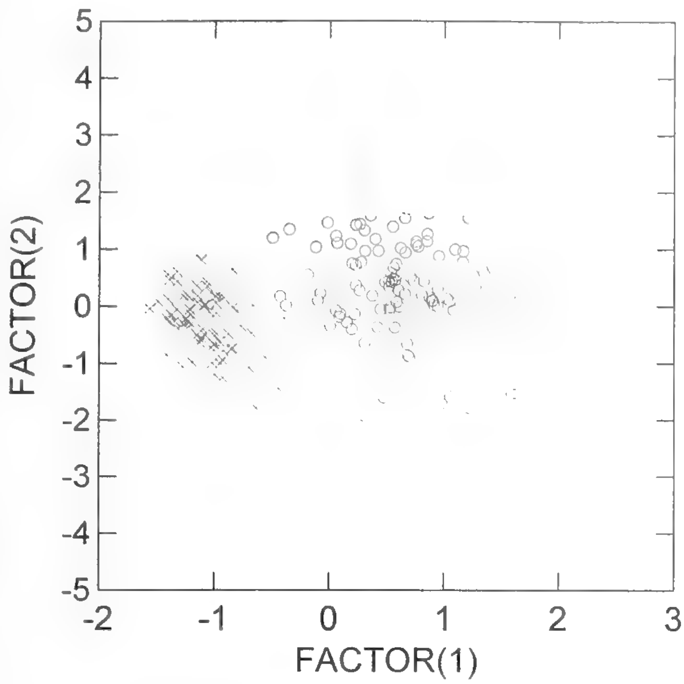


FIGURE 1. Principal component analysis on the quantitative morphological data set for the *Saxifraga nivalis* complex in the Canadian Arctic. Circles represent individuals of *S. nivalis*, crosses represent *S. tenuis*.

of the time, with one dimension accounting for the variation.

The PCA analysis examining geographical patterns to morphological variation in *S. tenuis* revealed very little geographical structure, with eastern arctic and high arctic plants almost completely overlapping. Western montane plants separated from the majority of arctic plants on a combination of both factors (with LFWIDTH, LFLENGTH, and TEETH, loading high on factor one, HEIGHT on factor two), but overlapped considerably with several eastern arctic plants. A discriminant function analysis performed on the three geographic groups produced similar results (correctly placing the western montane plants with 100% reliability, high arctic plants with 86% reliability, and eastern arctic plants with only 42% reliability).

Chloroplast DNA analysis

The *trn*H-*trn*K amplicons were estimated at 1600 base pairs (bp) for *S. nivalis* and *S. tenuis* and 1700 bp for *S. foliolosa*. The three largest regions, *trn*F-*trn*V, *trn*V-*rbc*L and *rbc*L-ORF106, were approximately 3000 bp in length in all three taxa. Interestingly, the *trn*T-*trn*F region was estimated to be 1800 bp, 1850 bp and 2000 bp in length for *S. nivalis, S. tenuis* and *S. foliolosa,* respectively.

Sixteen out of 105 enzyme restriction assays showed restriction site differences between *S. foliolosa* and the *S. nivalis* complex, including three site differences in the *trn*H-*trn*K region, three in the *rbc*L-ORF106 region, three in the *trn*V-*rbc*L region, five in the *trn*F-*trn*V region and two in the *trn*T-*trn*F region (Table 4). No restriction site differences were detected between *S. nivalis* and *S. tenuis*. However, digestion of the *trn*T-*trn*F region with the restriction enzyme *Alu*I showed clearly the length difference between *S. nivalis* and *S. tenuis* (Figure 2).

Table 4. Data matrix of restriction site characters for S. nivalis (N), *S. tenuis* (T) and *S. foliolosa* (F). "0" represents absence of restriction site; "1" represents presence of restriction site.

	***trn*H-*trn*K** N T F	***rbc*L-ORF106** N T F	***trn*V-rbcL** N T F	***trn*F-trnV** N T F	***trn*T-trnF** N T F
Alu I	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1
Apa I	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0
*Bam*H I	0 0 0	1 1 1	0 0 1	0 0 0	0 0 0
Bgl I	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0
Bgl II	0 0 0	1 1 1	0 0 0	1 1 0	0 0 0
*Bst*O I	0 0 1	1 1 1	0 0 1	0 0 0	1 1 1
Dra I	0 0 1	1 1 0	0 0 1	0 0 0	0 0 1
*Eco*R I	0 0 0	1 1 1	0 0 0	0 0 1	0 0 1
*Eco*R V	0 0 0	1 1 1	0 0 0	0 0 0	0 0 0
Hae III	1 1 1	0 0 1	1 1 1	0 0 1	0 0 0
Hha I	0 0 0	0 0 0	1 1 1	0 0 0	0 0 0
Hinf I	1 1 1	1 1 1	1 1 1	1 1 1	0 0 0
Msp I	1 1 1	1 1 1	1 1 1	1 1 1	0 0 0
Nci I	1 1 0	1 1 1	1 1 1	1 1 1	1 1 1
Pst I	1 1 1	1 1 1	0 0 0	0 0 0	0 0 0
Pvu II	0 0 0	0 0 0	1 1 1	1 1 0	0 0 0
Rsa I	0 0 0	1 1 1	1 1 1	1 1 1	0 0 0
*Sau*96 I	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1
Sin I	1 1 1	1 1 1	1 1 1	1 1 1	0 0 0
Taq I	0 0 0	0 0 1	1 1 1	1 1 1	1 1 1
Xho I	0 0 0	0 0 0	0 0 0	1 1 0	0 0 0

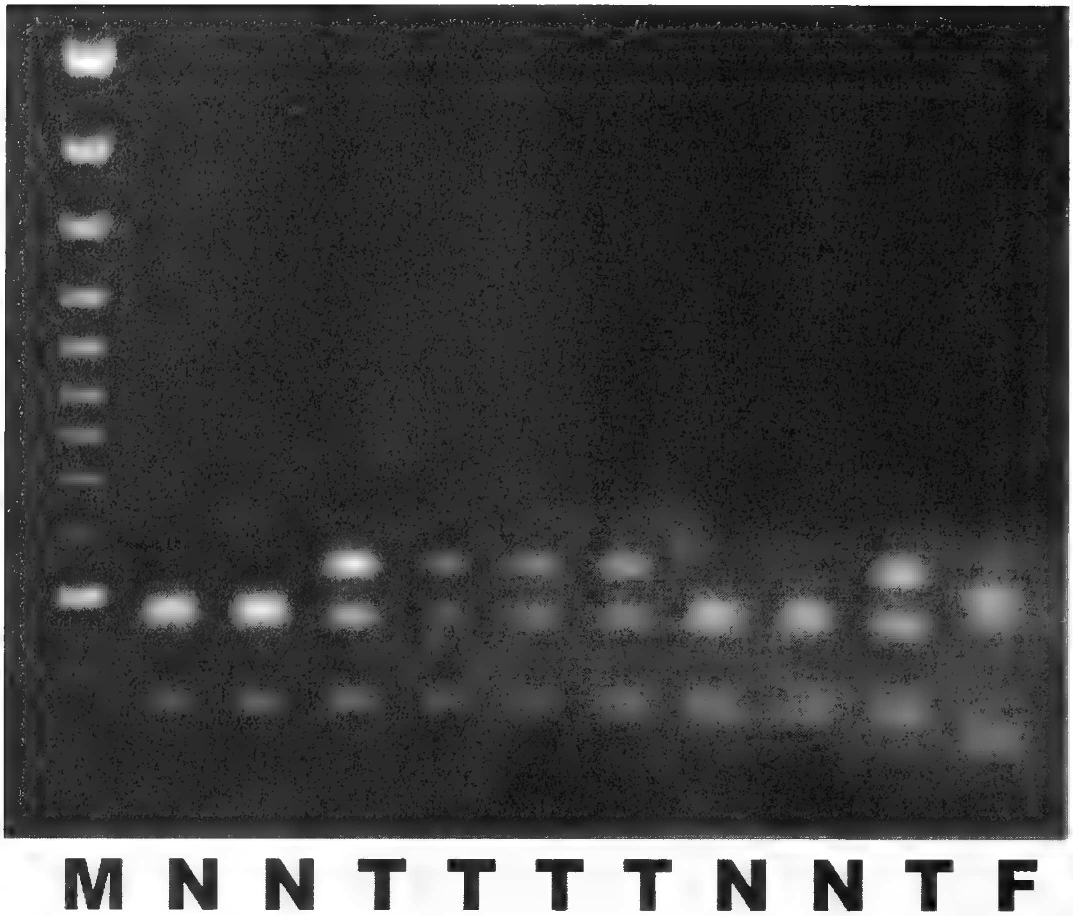


FIGURE 2. Digestion of the chloroplast DNA region *trn*T-*trn*F with restriction enzyme *Alu*I for *Saxifraga nivalis* (N), *S. tenuis* (T) and *S. foliolosa* (F). The first lane contains a 100 bp DNA size marker (M). Note absence of the upper band on *S. nivalis*.

Discussion

The principal component analysis confirms that the *S. nivalis* complex in the Canadian Arctic is represented by two principal morphotypes, appearing as adjacent clusters on the PCA graph. The several plants occupying an intermediate position between the two clusters displayed a somewhat intermediate morphology, but nevertheless could readily be assigned to one of the two taxa. For example, several specimens of *S. nivalis* from Prince Patrick Island (e.g., *Gillespie & Consaul 6869-4, 6926a-3*) were very small with slender flowering stems, characters typical of *S. tenuis*, but otherwise had the morphological characteristics of *S. nivalis*. Although character states or ranges overlapped for the majority of characters examined, differences between the two taxa were statistically significant for all quantitative and for three qualitative characters.

Morphological variability

A significant amount of variance was observed for most characters measured. Since the *S. nivalis* complex is considered an environmental indicator (Aiken et al. 1998, 2000*), the variability observed may be due to phenotypic plasticity and variation in environment. For instance, *S. nivalis* plants growing in harsher habitats are usually shorter and less robust (e.g., the very short plant shown in Figure 3) than those growing in more nourishing environments. Also plants of *S. nivalis* may be taller with more slender stems in shady microhabitats as a result of etiolation. Another contributor to variance is the time of collection. Since stems elongate in the fruiting stage, particularly in *S. nivalis*, plants collected later in the season are more likely to be taller than their younger counterparts. However, most examined collections of *S. nivalis* and *S. tenuis* made at the same time and site displayed significant height differences on average between the two taxa. Leaf characters, such as leaf size and teeth number and size, showed much variation both within and between the two taxa. Although *S. tenuis* is usually found in wetter habitats than *S. nivalis,* the latter species in particular occupies a broad range of habitats and the two species sometimes co-occur in mixed populations. Some of the morphological variation in the complex, particularly within *S. nivalis*, may reflect this variation in habitat (Blondeau and Cayouette 2002; Aiken et al. 2000*). Such high intraspecific variation is apparently typical of Saxifrages, particularly in arctic and alpine environments, and several studies have demonstrated that such variation may not be of taxonomic significance (Soltis et al. 1996; Brysting et al. 1996).

The coloration of petals also varied within each taxon, but season and environment can be a large con-

FIGURE 3. *Saxifraga nivalis* complex in the Canadian Arctic. A. *S. tenuis* (*Gillespie & Consaul 6978-2*), habit. B. *S. nivalis* (*Gillespie and Consaul 6977-1*), habit. C. Comparison of basal rosette of leaves of *S. tenuis* (on left, *Gillespie & Consaul 6978-2*) and *S. nivalis* (on right, *Gillespie and Consaul 6977-1*). A and B are the same scale.

tributor to petal coloration. Plants growing in more open, sunnier environments tend to have more pink or dark red anthocyanin pigment throughout the plant, including the petals. White petals may also sometimes turn pinkish with age. In contrast, little variation was observed within each taxon for the texture and coloration of stem hair, and these characters were significantly different between taxa.

Among traits traditionally used for identification of the *S. nivalis* complex, many displayed considerable intrataxon variance, with ranges often overlapping between taxa. Our results also indicate a greater degree of variability within *S. nivalis* than in *S. tenuis* in the Canadian Arctic. This pattern of variation results in a somewhat obscure morphological boundary between the two species and has led to difficulties in constructing good identification keys.

Characters and taxonomic identification

Despite the considerable intraspecific variation, most commonly used identification characters were significantly different between the two taxa. Indeed, plants of *S. nivalis* were overall larger and more robust than *S. tenuis*, and the latter often had a more reddish tinge on the petals and stem hair, as previously found by numerous authors (Simmons 1906; Polunin 1940; Porsild 1957; Böcher et al. 1968; Löve 1983; Blondeau 1989a; Webb 1993).

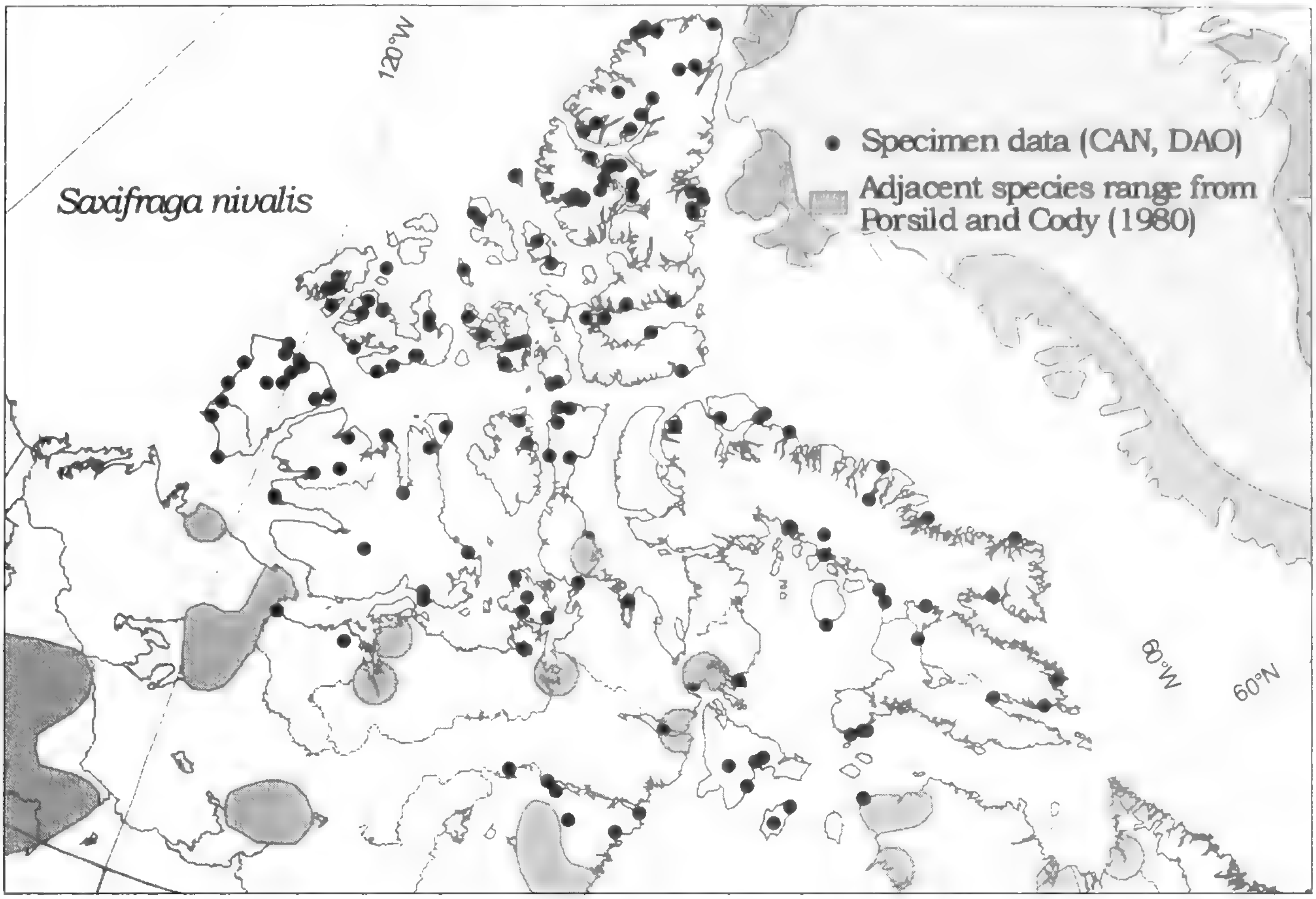
Flowering stem width was an excellent identification character apart from a few individuals, with *S. tenuis* characterized by a width of 1 mm or less, consistent with Webb's (1993) use of it as a key character. Consistently used by various botanists (e.g., Webb 1993), stem hair characters were among the most useful for identification. *Saxifraga nivalis* usually has a much more conspicuous, longer, denser, coarse crisped white vestiture, while *S. tenuis* has a less conspicuous, shorter, finer, usually glandular pubescence. Canadian Arctic *S. tenuis* was found to always have stem hairs, thus not conforming to descriptions of the taxon in Greenland and Svalbard as having mostly glabrous stems (Böcher et al. 1968, 1978; Rønning 1996). Generally, *S. nivalis* plants were taller than *S. tenuis*, but due to its variance, height was not useful for identification.

Saxifraga nivalis had more numerous teeth on the leaves than *S. tenuis,* and the latter had rounder obtuse teeth versus more pointed, as suggested in the literature (e.g., Böcher et al. 1968), The width and length of *S. tenuis* teeth were also found to be less than those observed on *S. nivalis*, but, this is not surprising considering that *S. nivalis* had on average longer and wider leaves. Interestingly, *S. nivalis* had a notably less regular dentition than *S. tenuis* in regards to the size of the teeth. The former generally had small teeth at the base with teeth becoming larger towards the apex, whereas *S. tenuis* had more evenly sized teeth. Although size of the largest leaf differed significantly between the two taxa, leaf size characters make poor diagnostic characters due to overlap and age related variation. Also, leaf shape varied tremendously and thus should not be considered a good discriminating character. However, the leaf apices of *S. tenuis* did tend to be more rounded than those of *S. nivalis*.

Inflorescence compactness provides a useful identification character, with *S. nivalis* having one or more compact head-like clusters and *S. tenuis* a more open inflorescence (as described in Porsild 1957). Flower pedicels, especially of the lowermost flowers, are longer in *S. tenuis* than in *S. nivalis*. Since pedicels of the latter may elongate somewhat in fruit, this difference may be obscured later in the season. Although not constant, petals tend to be whiter, wider and ovate in *S. nivalis* and pink, narrower, more elongated and rounder at the apex in *S. tenuis*. Böcher (1938), Böcher et al. (1968), and more recently Löve (1983) and Rønning (1996) state that *S. nivalis* has straight or slightly spreading styles, while *S. tenuis* has styles that curve strongly downwards. This was not always the case in Canadian Arctic specimens we examined. The way specimens were pressed and the time of collection might be partly responsible for the variation in this character within the two species.

Other characters showed variation that was not useful in separating the two taxa. While *S. nivalis* usually had hairs on leaf margins, this character was also found to a lesser degree in *S. tenuis*. Most specimens examined had a purplish or reddish stem, thus not specific to *S. tenuis*. Also, the flowering stems of both taxa had on occasion a reduced leaf (bract) or two near the inflorescence, although usually more prominent in *S. tenuis*.

The presence of rust-coloured hairs on the lower surface of the leaves of *S. tenuis* has been commonly used to distinguish it from *S. nivalis* in the Canadian Arctic, and was used as a key character by several authors (Porsild 1957; Scoggan 1978; Porsild and Cody 1980). However, this study reveals that hairs are present on the leaf undersurface in over 99% of the plants examined of both species in the Canadian Arctic, and that hairs may be rust-coloured in both species, about 42% of *S. nivalis* plants examined and 74% of *S. tenuis* plants. This error may have resulted from Porsild's inclusion of *S. rufopilosa* within his concept of *S. tenuis* (distribution maps of *S. tenuis* in Porsild (1957) and Porsild and Cody (1980) appear to have included *S. rufopilosa*). *Saxifraga rufopilosa*, a species now considered to be endemic to unglaciated areas of the Yukon and Alaska, is characterized by a mat of long crinkly rusty hairs on the leaf undersurface (Cody 1996), much longer and denser than in either *S. tenuis* or *S. nivalis*. Whatever its origin, use of rust-coloured hair presence as a key diagnostic character in identifying Canadian Arctic material of the *S. nivalis* complex resulted in many misidentified specimens and much confusion as to the identity of *S. tenuis*.



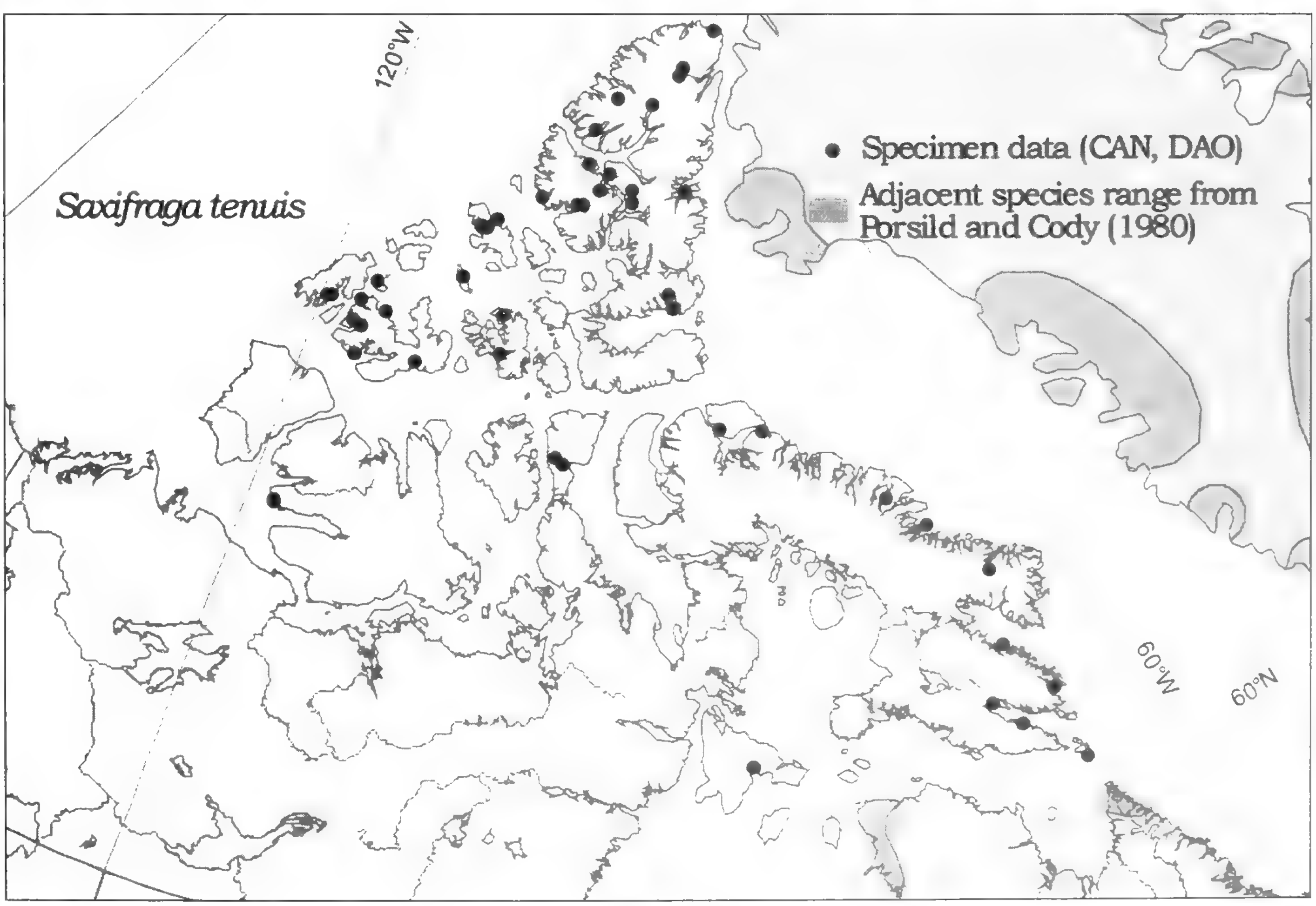


FIGURE 4. Distribution of the *Saxifraga nivalis* complex in the Canadian Arctic. (above) *S. nivalis*. (below) *S. tenuis*. Shading indicates approximate distribution outside of the Arctic Islands (from Porsild and Cody 1980, and CAN and DAO herbarium records).

The many herbarium collections having both *S. nivalis* and *S. tenuis* plants on the same sheet and under the same number (e.g., *Bruggeman 358, Savile 4562, Macdonald 150, Calder et al. 24149*) shows just how problematic identification of this complex in the Canadian Arctic has been. About 20% of herbarium specimens identified as *S. tenuis* at both CAN and DAO were in fact mixed collections including both *S. tenuis* and *S. nivalis* plants, or less often including small plants of *S. foliolosa* or *S. hieracifolia* Waldst. & Kit. Previous identification problems of the *S. nivalis* complex in the Canadian Arctic may also have been due to misinterpretation of key characters. For example, *S. nivalis* with several flower heads could be keyed out under lax (open) inflorescence.

Although *S. nivalis* and *S. tenuis* can be readily distinguished in the Canadian Arctic, a small percentage of specimens had one or a few characteristics of the other species. For example, some high arctic *S. nivalis* had very slender stems or fruit with strongly recurved styles. While this may be part of the natural variation within *S. nivalis*, it may also suggest a low level of hybridization. Some of the overlap in quantitative character states shown in our morphological analyses may also be the result of hybridization. Recent cytological studies have suggested the existence of S. *nivalis-S. tenuis* hybrids (2n = 40) in regions of the Russian Arctic and the Yukon where *S. nivalis* and *S. tenuis* are found growing together (Krause and Beamish 1973; Devyatov et al. 1997). The population in the Gaspé Peninsula has the same intermediate chromosome number and may represent a stabilized relictual hybrid in an area whether neither parent now occurs (Gervais et al. 1995). In addition Polunin (1959) suggested that hybridization may also occur between the *S. nivalis* complex and other closely related species, such as *S. hieracifolia*.

Geographical variation in *Saxifraga tenuis*

Savile (1961) proposed that North American *S. tenuis* may be divided into three disjunct and morphologically distinct "populations." The first is a high arctic population composed of plants identical to material from the north of Greenland and hypothesized to have spread from there following the Pleistocene. The second population is apparently found mostly along Hudson Straight in southern Baffin Island, northernmost Quebec and Southampton Island, but also scattered northward to northeast Baffin Island. Savile treated plants in the Gaspé Peninsula of Quebec, considered by some as a separate species *S. gaspensis*, as part of this population. Plants of this population apparently tend to be larger and less purplish in colour than in the high arctic. The third highly variable population, found in Alaska and the Yukon, is usually characterized by a highly purplish pigmentation and whitish scape hairs, and was suggested to be intermediate between *S. nivalis* and high arctic *S. tenuis*.

Our analysis indicates that eastern and high arctic plants of *S. tenuis* cannot be distinguished based on examined quantitative characters, while western montane plants (based on our small sample size) may be differentiated from most arctic plants based on larger size. Since Savile (1961) used mostly qualitative characters to distinguish the three groups, further analyses based on both qualitative and quantitative characters and including more western montane and eastern arctic specimens should be made to further test his hypothesis.

Chloroplast DNA analysis

The five non-coding cpDNA regions of *S. nivalis* and *S. tenuis* were identical for restriction sites assayed. Considering the conservative nature of cpDNA evolution, it is not surprising to observe such similarity, with closely related species often having identical cpDNA restriction site profiles (Olmstead and Palmer 1994). However, *S. nivalis* and *S. tenuis* displayed an estimated 50 bp length difference in the *trn*T-*trn*F region. This difference was observed both among plants from the same site and from different locations. This suggests that the size variation in the *trn*T-*trn*F region is not background variation among populations or a phenomenon limited to a particular population, but represents a molecular difference between *S. nivalis* and *S. tenuis,* either a deletion event in *S. nivalis* or an insertion event in *S. tenuis*. Sequencing of the *trn*T-*trn*F region would prove useful in specifying the nature of this size difference. The RFLP analysis revealed molecular differences for 16 of 105 restriction enzyme assays between *S. foliolosa* and the other two species. These results are similar to a study of *Saxifraga* based on the cpDNA *mat*K sequences (Soltis et al. 1996; plus sequences in Genbank), in which *S. nivalis* and *S. tenuis* would appear to be more closely related to each other than to *S. foliolosa*. Based on comparison of the Genbank sequences, the single plant of *S. tenuis* differed from *S. nivalis* in four nucleotide substitutions, and from *S. foliolosa* in 79 substitutions.

Implications

Our results suggest that *S. nivalis* and *S. tenuis* should be recognized as distinct taxa, and are most appropriately recognized at the species level following Porsild (1957), Porsild and Cody (1980), and Webb (1993). The two taxa are distinguishable at both the molecular and cytological level and have morphological differences that correspond to these differences. Although no morphological characters give 100% separation, many quantitative and qualitative characters show statistically significant differences between the two taxa. The two taxa overlap in geographic distribution in the Canadian Arctic, with the range of the less common *S. tenuis* included within that of *S. nivalis*. Although ranges of habitat preferences differ, there is considerable overlap, with the two taxa sometimes occurring in mixed populations. Lack of geographical

separation and considerable habitat overlap make recognition at the subspecific level inappropriate, while the morphological distinctiveness of the two taxa would make recognition at the varietal level inappropriate.

Saxifraga nivalis complex in the Canadian Arctic: key to species

A. Inflorescence one to several dense head-like clusters of numerous flowers; petals white or essentially so (sometimes becoming pink with age); flowering stem (0.5-) 1-2.5 mm wide, moderately to densely hairy, with conspicuous long coarse white hairs; plant usually robust in appearance *S. nivalis*

B. Inflorescence an open cyme of fewer flowers, flowers on distinct pedicels; petals pink or less often white; flowering stem 0.3-1 mm wide, usually sparsely hairy, with short fine hairs that are usually inconspicuous; plant delicate in appearance *S. tenuis*

Saxifraga nivalis L.

Plants perennial herbs, (2) 5–17 cm high, with a basal rosette of leaves. Leaves simple, alternate, all basal in a rosette, evergreen; petiole usually distinct, 0.2–2.5 mm long. Leaf blade ovate, obovate, orbicular or spatulate, 6–36 mm long (mean 14 mm), 4–21 mm wide (mean 10 mm), slightly leathery; green above, green or reddish-purple beneath, base obtuse and usually abruptly narrowed at petiole; apex obtuse, rounded or rarely acute; appearing single-veined or with inconspicuous lateral veins; upper surface glabrous; lower surface sparsely to densely hairy; hairs 0.2-1.2 mm long, rust-coloured, whitish or translucent; margins coarsely serrate or crenate, usually with rust-coloured or whitish hairs; teeth 7-14, usually increasing in size towards blade apex, tips usually pointed. Flowering stem erect, (0.5) 1-2.5 mm wide, green to purple, moderately to densely hairy, with hairs conspicuous, (0.5) 0.7-1.2 mm long, crisped (crinkly and irregularly wavy), white or translucent with tips and crosswalls white or sometimes rust-coloured or purplish, the tips sometimes glandular, usually leafless or occasionally with reduced leaves (bracts) close to the inflorescence. Inflorescence a dense head-like cluster of numerous flowers, sometimes with 1-2 smaller lateral clusters on short to long peduncles; flowers on very short pedicels, subtended by bracts. Flowers: sepals 5, free, green or purple, glabrous; petals 5, ovate or elliptic, 0.7-1.8 mm wide, equal to or longer than the sepals, white or cream-coloured, sometimes with reddish apex, mostly obtuse at apex; stamens 10; gynoecium partly inferior; carpels 2, partly fused; styles 2, free; placentation axile; ovules numerous. Fruit a capsule, spherical in lower half, with straight or slightly divergent free carpels above, 3–4 mm long, 4.5–5.5 mm wide, glabrous, dry, dehiscent; styles straight or slightly divergent, persistent; sepals persistent in fruit. Seeds numerous, 0.5–1 mm long, yellowish brown, with surface verrucose. Figure 3b, c; map 4a.

Saxifraga tenuis (Wahlenb.) Harry Sm.

Plants perennial herbs, 2–9 cm high, with a basal rosette of leaves. Leaves simple, alternate, all basal in a rosette, evergreen; petiole usually indistinct, ~0.5–2.5 mm long. Leaf blade narrowly ovate, obovate or spatulate, 4–15 mm long (mean 7 mm), 2–8 mm wide (mean 5 mm); slightly leathery, green to reddish-purple above, reddish-purple beneath; base obtuse or broadly attenuate and decurrent onto petiole; apex obtuse, rounded or rarely acute; appearing single-veined or with inconspicuous lateral veins; upper surface glabrous; lower surface usually sparsely hairy, with hairs 0.1-0.4 mm long, rust-coloured, whitish or translucent; margins coarsely serrate or crenate, with sparse rust-coloured or whitish hairs or sometimes glabrous; teeth 6-9, usually evenly sized, tips usually rounded. Flowering stem erect, 0.3-1 mm wide, usually dark purple, sparsely hairy, with hairs mostly inconspicuous, 0.1-0.3 (0.5) mm long, fine, crinkled or straight, rust-coloured to translucent, often with purplish crosswalls and tips, the tips usually glandular; sometimes with a reduced leaf (bract) on the upper part of the stem. Inflorescence an open head of few flowers; flowers subtended by bracts; lower-most flowers often long-pedicellate and each subtended by a conspicuous bract. Flowers: sepals 5, free, green or purple, glabrous; petals 5, ovate or elliptic, 0.5-1.1 mm wide, equal to or longer than the sepals, usually pink, sometimes white, often with reddish apex, often rounded at apex; stamens 10; gynoecium partly inferior; carpels 2, partly fused; styles 2, free; placentation axile; ovules numerous. Fruit a capsule, spherical in lower half, with diverging free carpels above, 3–4 mm long, 4.5–5.5 mm wide, glabrous, dry, dehiscent; styles usually strongly re-curved at maturity, persistent; sepals persistent in fruit. Seeds numerous, 0.5–1 mm long, yellowish brown, with surface verrucose. Figure 3a, c; map 4b.

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Appendix 1: Collections examined of the *Saxifraga nivalis* complex from the Canadian Arctic.

Saxifraga nivalis

NUNAVUT. **Axel Heiberg Island:** 79°28'N 87°40'W, *Beschel 10979* (CAN); Bukken River, 80°31.57'N 92°21.83'W, *Gillespie et al. 6613* (CAN); Crusoe Glacier, 97°27'N 91°12'W, *Kuc 476-3* (CAN); Crusoe River, 79°24'N 90°50'W, *Kuc s.n.* (CAN 331187); Diana Lake, 79°30'N 88°30'W, *Porsild 16699-2* (CAN); Expedition Fjord, 79°20'N 92°W, *Kuc s.n.* (CAN 331189, CAN 331189); Mesa Brook, 79°37'N 95°W, *Beschel 13129* (CAN); Mokka Fiord, 79°45'N 87°W, *Parker 73061E* (CAN). **Baffin Island:** 63°24'N 64°35'W, *McLaren 91* (CAN); 66°40'N 70°W, *Soper s.n.* (CAN 65150); Admiralty Inlet, 73°13'N 84°W, *Malte 118993* (CAN); Apex, 63°43'N 68°27'W, *Gillespie & Soreng 6785* (CAN); Beekman Peninsula, 63°24'N 64°35'W, *McLaren 91* (CAN); Burwash Bay, 65°59'N 71°18'W, *Jacobs & Maus s.n.* (CAN 517697); Frobisher Bay, 63°45'N 68°31'W, *Gillett 19018* (CAN); Dorset Island, 64°12'N 76°32'W, *Hainaud & Norman 5698* (CAN); Foxe Peninsula, 66°23'N 83°13'W, *Manning 265* (CAN); Foxe Peninsula, 69°52'N 76°54'W, *Manning 231* (CAN); Frobisher Bay, 62°57'N 66°03'W, *Aiken et al. 86-260* (CAN); Frobisher Bay, 63°44'N 68°27'W, *Aiken et al. 86-493* (CAN); Frobisher Bay, 62°57'N 66°03'W, *Calder et al. s.n.* (DAO 24148); Frobisher Bay, 62°57'N 66°03'W, Wynne-*Edwards 7353* (CAN); Pond Inlet, 72°50'N 76°40'W, *Dutilly 1224a* (CAN); Stising Valley, *Weber 94* (CAN); Taverner Bay, 67°12'N 72°25'W, *Manning 44, 68, 77* (CAN). **Bathurst Island:** Polar Bear Pass, 75°43'N 98°23'W, *Aiken & Maus 92-022* (CAN); Goodsir Inlet, 75°45'N 97°45'W, *Lamothe 69-25* (CAN); Polar Bear Pass, 75°43.8'N 98°25.45'W, *Gillespie & Consaul 6984* (CAN) [DNA voucher, individuals 1-5 examined]. **Bylot Island:** 72°53'N 76°W, *Wilcox 125631* (CAN). **Cameron Island**: 76°19.5'N 104.5°W, *Aiken 92-039* (CAN). **Cornwallis Island:** Resolute, 74°40'N 94°50'W, *Aiken & MacCormac 98-055* (CAN 581909, plants 1-5; CAN 582554); Resolute, 74°40'N 95°04'W, *Aiken et al. 93-072* (CAN). **Devon Island:** Dundas Harbour, 74°31.3'N 82°33.5'W, *Gillespie et al. 6675-1* (CAN); Truelove Lowland, 75°40'N 84°40'W *Kerik s.n.* (CAN 409363). **Digges Island:** 62°32'N 77°45'W, *Gaston 25, 29* (CAN); 62°35'N 77°50'W, *Gaston 17* (CAN). **Ellef Ringnes Island:** Isachsen, 78°47'N 103°50'W, *Macdonald 242* (CAN). **Ellesmere Island:** 79°34'N 84°44'W, *Edlund & Roncato-Spencer 264* (CAN); Alexandra Fiord, 78°53'N 75°45'W, *Gillespie & Vogel 6165* (CAN); Alexandra Fiord, 78°53'N 75°50'W, *Gillett & Shchepanek 18108* (CAN); Craig Harbour, 76°20'N 81°30'W, *Dutilly 1267* (CAN); Hazen, 68°30'N 72°45'W, *Soper 8194* (CAN); Hazen, 81°49'N 71°20'W, *Gillespie & Vogel 6238* (CAN); Sawtooth Range, 79°43.54'N 83°09.44'W, *Gillespie et al. 6643* (CAN); Slidre Fjord, 80°N 86°15'W, *Tener 95* (CAN); Tanquary, 78°53'N 75°45'W, *Gillespie & Vogel 5982* (CAN). **King William Island:** Gjoa Haven, *Cooper 28* (CAN), *73* (CAN), *226* (CAN); Gjoa Haven, 68°38'N 95°53'W, *Larson 25* (CAN); Victory Point, *Cooper 164* (CAN), *122* (CAN). **Lougheed Island:** 77°30'N 105°38'W, *Edlund 2091* (CAN). **Meighen Island:** 79°55'N 99°30'W, *Kuc* (CAN 331171). **Pelly Bay:** 68°53'N 89°51'W, *Campbell s.n.* (CAN 282778). **Prince Charles Island:** 67°10'N 76°43'W, *Baldwin 1919* (CAN). **Victoria Island:** 68°53'N 105°W, *Edlund & Argus 12730-1* (CAN).

NORTHWEST TERRITORIES. **Banks Island:** 73°N 117°W, *Aiken 99-203* (CAN); 73°24'N 117°0'W, *Porsild 17711* (CAN); 74°31'N 121°07'W, *Manning & Macpherson 164* (CAN); Bernard River, 73°22'N 121°47'W, *Maher & Maclean 75* (CAN); Egg River, 72°27'N 124°36'W, *Lambert s.n.* (CAN 535943); Lambton, 71°05'N 123°09'W, *Porsild 17579* (CAN); Shoran Lake, 71°51'N 113°23'W, *MacInnes s.n.* (CAN 535570, 535598, 535733). **Fitzwilliam Owen Island:** 77°07'N 113°47'W, *Kuc s.n.* (CAN 331114). **Melville Island:** 75°56'N 114°48'W, *Edlund & Aiken 148* (CAN); Canrobert Hills 75°47.30'N 115°56'W, *Edlund 179* (CAN); Ibbett Bay, 75°54'N 114°30'W, *Edlund 43* (CAN); Kitson River, 76°02'N 113°05'W, *Edlund 18* (CAN); Marie Bay 76°12'N 114°55'W, *Edlund 305* (CAN); McCormick Inlet, 75°46.2'N 112°31.64'W, *Gillespie & Consaul 6977* (CAN, plants 1, 2), *6964a* (CAN); Shellabear Point, 71°51'N 113°23'W, *Edlund 115* (CAN); Sherard Bay, 76°08'N 108°07'W, *Dugal s.n.* (CAN 535598); Winter Harbour, 74°17'N 110°42'W, *Kuc s.n.* (CAN 400104); Winter Harbour, 74°17'N 110°42'W, *Tener & Harington 149* (CAN). **Prince Patrick Island:** Green Bay, 76°33.67'N 118°53.09'W, *Gillespie & Consaul 6869* (CAN, plants 1-6); Intrepid Inlet, 76°22.01'N 118°35.45'W, *Gillespie*

& Consaul 6876 (CAN); Mould Bay 76°12N 119°25'W, *MacDonald 146* (CAN); Mould Bay, 76°14.50'N 119°21'W, *Gillespie & Consaul 6806* (CAN, plants 1-5); Mould Bay, 76°14'N 118°57'W, *Gillespie & Consaul 6827* (CAN, plants 1, 2), *6826* (CAN, plants a1-a5); Mould Bay, 76°21.50'N 119°30.50'W, *Gillespie & Consaul 6884* (CAN, plants 1, 2), *6984* (CAN, plants 1-5), *6806* (CAN, plants 1-5). **Victoria Island**: Minto, 71°34'N 115°21'W, *Edlund 594* (CAN).

Saxifraga tenuis
NUNAVUT. **Axel Heiberg Island:** Bastion Ridge, 79°21'N 90°48'W, *Beschel 12920* (CAN); Mesa Brook, 79°35'N 95°30'W, *Beschel 13129* (CAN 295548); 80°17'N 88°27'W, *Scotter & Zoltai 45133* (DAO), *45181* (DAO). **Baffin Island:** Resolution Island, 61°20'N 64°55'W, *Wynne-Edwards 7225* (CAN); Erik Harbour, 72°40'N 76°30'W, *Calder s.n.* (DAO 30869, 30871); Ogac Lake, 62°51.7'N 67°21'W, *McLaren s.n.* (CAN 274125); Frobisher Bay, 63°45'N, 68°32'W, *Senn 3658* (DAO); Blackhead Island, 64°59'N 66°19'W, *Soper s.n.* (CAN *125598*); Savage Islands, 61°49.15'N 65°42.62'W, *Gillespie et al. 6728* (CAN), *6732* (CAN); Inugsuin Fjord, 69°50'N 69°08'W, *Beschel 3649A* (CAN). **Bathurst Island:** 76°36'N 100°04'W, *Blake 24a* (DAO). **Bylot Island:** 73.03'N 80.07'W, *Scotter & Zoltai 6751A* (DAO). **Ellef Ringnes Island:** Isachsen, 78°49'N 103°37'W, *Savile 4275* (DAO), *4219* (DAO), *4224* (DAO), *4285* (DAO), *4355* (DAO), *4293* (DAO); Isachsen, 78°47'N 103°30'W, *MacDonald 251* (CAN), *252* (CAN); Christopher Peninsula, 78°59'N 101°35'W, *Savile 4194* (DAO); 78°45'N 102°50'W, *Savile 4148* (DAO). **Ellesmere Island:** Eureka, 79°59'N 85°50'W, *Scotter & Zoltai 45294-B* (DAO); Eureka, 80°10'N, 85°39'W, *Bruggemann 805* (DAO); Fosheim Peninsula, 79°34'N 84°44'W, *Edlund & Roncato-Spencer 262* (CAN 535348, 533280); Fosheim Peninsula, 79°58'N 84°26'W, *Edlund & Roncato-Spencer 275* (CAN); Hazen, 81°49'N 71°21'W, *Savile 4485* (DAO), *4752* (DAO), *4655* (DAO); Hazen, 81°45'N 68°30'W, *Powell 338* (CAN); Hazen, 82°N 70°W, *Soper 8273* (CAN); Makinsen Inlet, 76°41'N 81°37'W, *Blake 7* (DAO); Mount Pullen, 82°25'N 62°17'W, *MacDonald 46* (CAN); 81°45'N 62°11'W, *Powell 520* (CAN); Mt. Pullen, 82°26'N 62°11'W, *Bruggemann 215* (DAO); Tanquary Fjord, 79°12'N 83°29'W, *Brassard 3306* (CAN); Van Hauen Pass, 81°07'N 86°55'W, *Brassard 3047* (CAN); Vesle Fjord, 79°12'N 83°29'W, *Edlund & Roncato-Spencer 282* (CAN). **Somerset Island:** 72°56'N 94°57'W, *Zoltai 741044* (DAO).
NORTHWEST TERRITORIES. **Melville Island:** 74°58'N 115°02'W, *Parker 44f* (DAO); Bailey Point, 74°58'N,115°02'W, *Parker 48b* (DAO); McCormick Inlet, 75°46.2'N 112°31.64'W, *Gillespie & Consaul 6978* (CAN, plants 1, 2), *6964b* (CAN). **Prince Patrick Island:** Green Bay, 76°33.67'N 118°53.09'W, *Gillespie & Consaul 6870* (CAN, plant 1); Intrepid Inlet, 75°46.9'N 112°22.09'W, *Gillespie & Consaul 6877* (CAN, plant 1); Mould Bay, 76°21.5'N 119°30.5'W, *Gillespie & Consaul 6881* (CAN, plants 1-6); Mould Bay, 76°14'N 118°57'W, *Gillespie & Consaul 6825* (CAN, plants 1-3); Mould Bay, 76°14.5'N 119°21'W, *Gillespie & Consaul 6807* (CAN, plants 1-5). **Victoria Island:** Ulusartok Peninsula, 70°44'N 117°44'W, *Edlund 875* (CAN).
ALASKA. Kenai Peninsula. 60°49'N 149°33'W, *Calder 6511*, *6249*, *6107* (DAO).
BRITISH COLUMBIA. Haines Junction, *Calder & Kukkonen 28151* (DAO); Haines, *Taylor et al. 1204* (DAO).

Mixed collections - *Saxifraga tenuis* and *Saxifraga nivalis* on same sheet
NUNAVUT. **Baffin Island:** Apex, 63°43'N 68°27'W, *Calder et al. s.n.* (DAO 24149); Home Bay, 68°45'N 67°10'W, *Smith VP-53-61* (CAN). **Ellesmere Island:** Tanquary Fjord, 79°12'N 83°29'W, *Brassard 3317* (CAN); Hazen, 81°49'N 71°21'W, *Savile 4562* (DAO).
NORTHWEST TERRITORIES. **Victoria Island:** near Holman, 70°43'N 117°43'W, *Edlund 719* (CAN). **Prince Patrick Island:** Mould Bay, 76°12'N 119°25'W, *MacDonald 150* (CAN, *S. tenuis*: 1, 3, 4, 7, 8, 9; *S. nivalis*: 2, 5, 6, 10).

The Influence of Prey Availability and Vegetation Characteristics on Scent Station Visitation Rates of Coyotes, *Canis latrans*, in a Heterogeneous Environment

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We investigated the effects of local prey fluctuations and habitat variables on the scent station visitation rates of the Coyote (*Canis latrans*) in northern Illinois within a heterogeneous environment. Availability of small mammalian prey was assessed by monthly mark-recapture sampling and visual counts conducted along three, 192-m transects in each of seven habitats that ranged from grassland to wooded sites. Habitat metrics, which included foliage density, ground cover, and canopy cover, were also collected for the same seven habitats. Visitation rates of Coyotes were determined from scent station lines parallel to the small mammal trapping transects. A multiple regression analysis indicated that Coyote visitation rates across the study site were influenced positively by vole (*Microtus* spp.) abundance and negatively by canopy cover. When Coyote visitation rates were regressed on vole abundance for only the habitats in which voles occurred, the relationship was not significant. This may be attributed to the general avoidance of wooded areas by Coyotes. Coyotes did, however, respond to experimentally-induced abundant patches of *Peromyscus*. These findings suggest Coyotes selectively use grassland habitats within a heterogeneous environment and may modify their use according to prey availability.

Key Words: Coyote, *Canis latrans*, habitat use, heterogeneous environment, prey availability, scent station, Illinois.

The Coyote, *Canis latrans*, is among the most adaptable of North American predators. Across an expansive range, the species occupies a variety of habitats and consumes a diversity of foods (Bekoff 1978). As such, the Coyote has been the focus of various local and regional studies of distribution, activity patterns, and diet selection. In particular, spatial and temporal activity patterns have been explicitly described (e.g., Andelt and Gipson 1979; Holzman et al. 1992), yet there has often been only circumstantial evidence as to causal factors (e.g., Person and Hirth 1991). Understanding potential determinants of Coyote spatial distribution and activity patterns requires an understanding of factors such as diet composition and specific use of available habitat types.

Predators exhibiting flexible behavior patterns, such as Coyotes, provide an opportunity for studying possible rapid responses to prey availability. Previous studies have shown that diets (Andelt et al. 1987; Brillhart and Kaufman 1995; Todd et al. 1981) and temporal activities of Coyotes (Shivik and Crabtree 1995) can vary seasonally based upon prey availability. Because space use and movements of vertebrate predators are closely coupled to foraging behavior, Coyotes could also alter their spatial use patterns in response to changes in prey availability. However, vertebrate predators frequently move over large spatial scales, whereas their smaller prey tend to be restricted to specific habitats or patches within a habitat. The study of prey in only one or a limited number of locations used by the predators (Hamlin et al. 1984; Jaksic et al. 1993; Korschgen and Stuart 1972) may preclude accurate inferences on the foraging behavior of vertebrate predators. Thus, it is important to relate predator foraging behavior among habitats to prey abundances within habitats of heterogeneous landscapes (Dunk and Cooper 1994; Korpimäki 1994).

In addition to prey, variations in vegetation structure, such as foliage density and height, among different habitats can also influence the movements and activities of vertebrate predators (Clark et al. 1993; Lamberson et al. 1994), especially in fragmented landscapes. Habitat differences may constrain predator foraging in certain areas through predators selectively using or avoiding particular habitat types (DeJong 1995; Smallwood 1995). As a result, predators may not respond to changes in prey availability within certain habitats. However, vegetation measures used to quantify predator habitat use may also be related to or reflect prey usage (Anthony et al. 1981). Such inter-relatedness must be considered when making inferences of predator behavior.

We investigated the relationships of spatial and temporal distribution of prey and vegetation characteristics to the habitat visitation of Coyotes across a heterogeneous environment. We incorporated experimental manipulations of habitat and prey, along with natural perturbations, to elicit predator behavioral responses

within a relatively short time scale. Data collected on prey abundance and habitat variables were used to address whether scent station visitation rates of Coyotes vary among habitats and within a particular habitat in response to changes in prey availability.

Study Areas

The study site was located in northern Illinois at Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois (41°50'N, 88°15'W). Fermilab encompasses approximately 3200 ha and is characterized as a heterogeneous area, marked by distinct habitat boundaries. The areas surrounding Fermilab consisted of small open spaces of mainly agricultural land interspersed with light industry and residential neighborhoods, providing potential predator access into or out of the study site. The study was conducted at seven different locations within Fermilab, representing five habitat types: (1) oldfield, dominated by Queen Anne's Lace (*Daucus carota*) and Tall Goldenrod, (2) tallgrass prairie, dominated by Big Bluestem (*Andropogon gerardii*) and Indian Grass (*Sorgastrum nutans*); (3) brome grass field, dominated by Smooth Brome (*Bromus inermis*); (4) shrubby oldfield, a heterogeneous mix of dense shrubs and shrub-grassland mixture dominated by Tall Goldenrod (*Solidago altissima*) and Gray Dogwood (*Cornus racemosa*) with small stands of Trembling Aspen (*Populus tremuloides*); and (5) oak woodland, dominated by mature oaks (*Quercus* spp.), one woodland (Oak Woods I) characterized by less dense canopy (primarily *Q. macrocarpa* and *Q. rubra*) than the other (Oak Woods II; predominantly *Q. alba* and *Q. rubra*; Figure 1). These different habitats were chosen because they represented the heterogeneity of the study site and included all prey species potentially found in Coyote diets at Fermilab. A concurrent investigation indicated that three prey, voles (primarily Meadow Voles, *Microtus pennsylvanicus*, and rarely Prairie Voles, *M. ochrogaster*), Eastern Cottontails (*Sylvilagus floridanus*), and mice (*Peromyscus* spp.), constituted 39.4%, 31.3%, and 8.4% of the Coyote diets, respectively, which was at least two times greater than the proportion of any other prey item (Randa 1996).

Methods

Availability of prey

From March 1994 through May 1995, small mammal species compositions and abundances were estimated by mark-recapture live-trapping on three, 192 m transects located within each of the seven habitats (Figure 1). The transects were parallel and spaced from 70 to 85 m to help maximize their independence in relation to small mammal movements. At least 50 m was maintained from each transect to habitat boundaries to avoid edge effects. Seventeen trap stations were spaced at 12-m intervals along each transect, totaling 51 trap stations per habitat. One 23 × 9 × 7.5 cm Sherman live-trap, baited with a peanut butter and oats mixture, was placed at each station. All habitats were trapped for two nights on a monthly basis. Traps were checked early morning and late afternoon (ca. every 12 hr). Captured individuals were marked with a uniquely numbered eartag (Monel Number 1, National Band and Tag Co., Newport, Kentucky).

Nocturnal visual counts, using a high-powered spotlight (Woolf et al. 1993), were conducted for Eastern Cottontails in each of the seven habitats. The counts were conducted twice during each of the 15 small mammal trap sessions by sighting with binoculars, at one end and midway, along the small mammal trapping transects. Animals within ca. 25 m of the transect were counted. For the visual counts, the trapping transects were lengthened to 250 m, delineated by flagging at opposing ends, to allow for the larger spatial movements of rabbits. Care was taken not to double count animals potentially moving between transects.

For the experimental studies, fire was used as a means of manipulating prey. Tallgrass Prairie I was burned between the October and November 1994 small mammal surveys, a period of time when small mammal abundances peak in northern Illinois (Yunger 2002). This site was adjacent to Oak Woods I (Figure 1), which concurrently experienced a high acorn production year. Both habitats contained two closely related species of small mammals (*Peromyscus maniculatus*, the Deer Mouse, in the prairie and *P. leucopus*, the White-footed Mouse, in the woods), which were similar in body size and morphology. Numerical responses, caused by immigration of Deer Mice to prairie burns, have been documented previously (Cook 1959; Kaufman et al. 1983, 1988). Similarly, acorns have been shown to be an important local food source for mice (*Peromyscus* spp: Ostfeld et al. 1996; Wolff 1996). Consequently, we predicted a localized increase of *P. maniculatus* in Tallgrass Prairie I and *P. leucopus* in Oakwoods I. The proximity of these two habitats provided the opportunity to compare changes in Coyote habitat visitation following the manipulations of prey abundance.

Prey also was manipulated in Tallgrass Prairie II through food supplementation. From October 1994 through March 1995, 10 kg of commercial rodent chow was hand broadcasted at weekly intervals on two of four (i.e., two treatment and two control), 0.60-ha square plots. As part of a separate study on the population dynamics of small mammals (Yunger 2002), prey numbers were determined by monthly trapping on a 6 × 6 grid with 12-m spacing in each plot. Predator spatial and temporal visitation responses to resulting changes in prey due to the food supplementation experiment were also compared to the natural increase in acorns of Oak Woods I and to the prey response to experimental burning of Tallgrass Prairie I.

Visitation rates of Coyotes

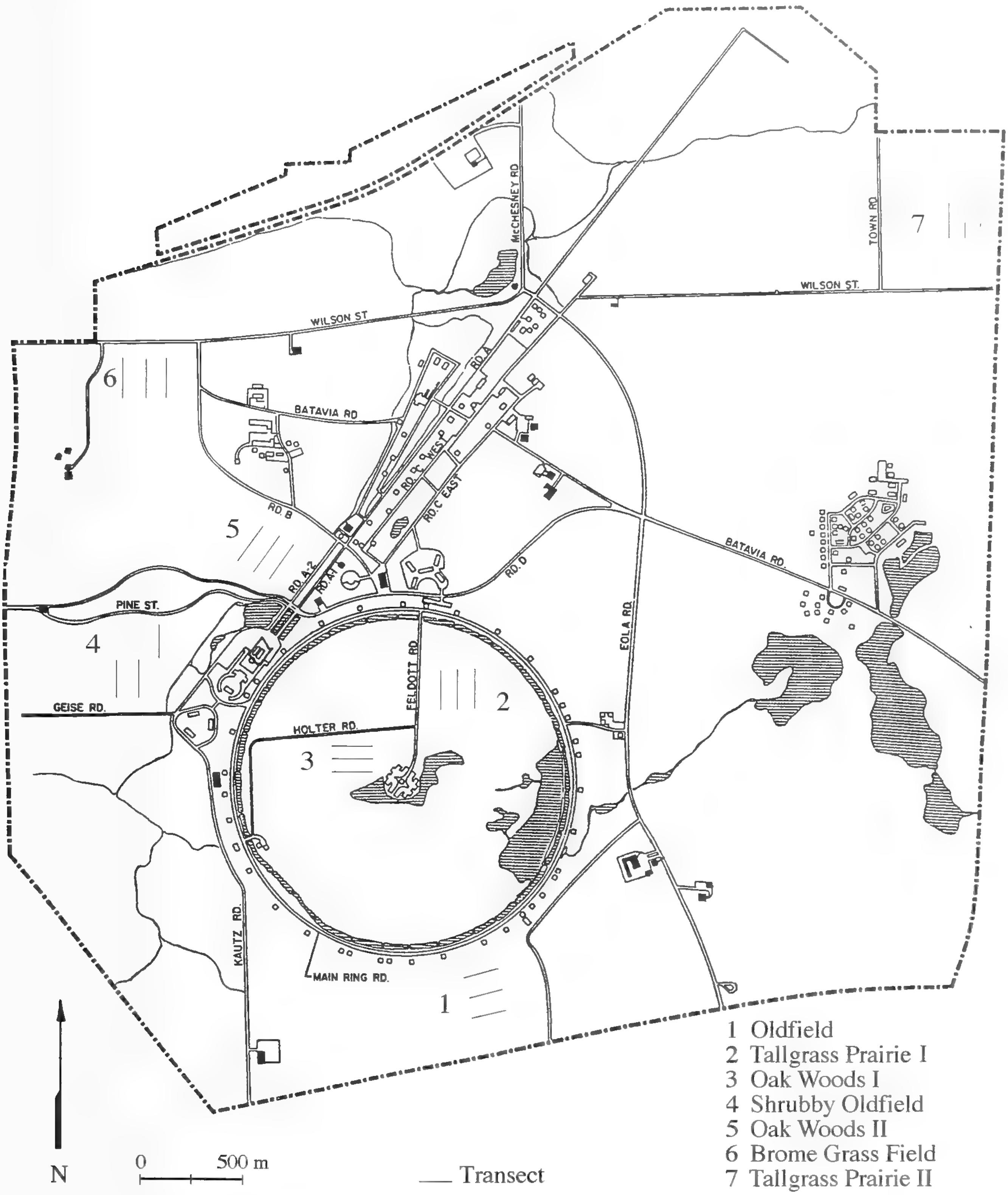

FIGURE 1. Map of Fermilab showing the seven different study locations (habitats) and approximate locations of scent station transects in each habitat. Dashed line represents boundary of Fermilab. Roads, buildings, and open water (dark shaded areas) are included to further depict heterogeneity of the study site.

Coyote visitation rates were monitored through the use of scent stations. These were constructed by excavating a 50-cm diameter by 10-cm deep circular depression, rimmed up to the ground surface with a 10-cm wide strip of aluminum flashing to inhibit invasive growth from surrounding vegetation, and filled with fine-grained sand. The resulting stations were level with the ground surface and fairly inconspicuous except for the lack of vegetation. Scent stations were located along 175-m transects, parallel to the small mammal trapping transects, in each of the seven locations. Transects were spaced ca. 100 m apart while maintaining at least 50 m from a transect to the habitat edge. Eight scent stations were spaced every 25 m along each transect in the seven habitats, for a total of 24 scent stations per location. At the start of each monitoring period, all scent stations were baited by placing a cotton swab dipped in a liquid commercial predator lure (Cronk's Predator 500, Wisscasset, Maine) upright in the middle of the scent station and the sand was smoothed. Stations were simultaneously monitored for a minimum of 2 nights (without precipitation), 1 to 3 times monthly (mean of 2.1 times per month); sand was not smoothed or otherwise disturbed by the authors during each monitoring period. Monthly scent station use was calculated for each habitat based upon visitation rates, or the proportion of scent stations exhibiting Coyote tracks in a given habitat, and divided by the total number of operative nights to account for any variation in sampling duration.

Within-habitat Coyote visitation rates were evaluated through the small mammal food supplementation experiment conducted in Tallgrass Prairie II. In January 1995, one scent station was placed at each corner of the four plots previously described for this habitat. These 16 stations were monitored from February 1995 through May 1995 to compare scent station visitation rates of Coyotes to prey numbers in supplemented and non-supplemented plots.

Vegetation analysis

Vertical foliage density, percent ground cover, and canopy cover were used to describe habitat structure for each of the seven habitats. Vegetation measurements were collected at 24 stations per habitat, along alternating stations of the small mammal trapping transects. Foliage density was measured using a modified profile board technique (MacArthur and MacArthur 1961). Percent cover of three, 30×50-cm profile boards, divided into 15, 10×10-cm cells, was measured at 0.5 m, 1.0 m and 1.5 m from ground to mid-level of the board. A cell was considered covered if 50% or more of the cell, viewed from a 5-m distance, was obstructed by vegetation. The proportion of cells covered determined percent cover of an individual board. All readings were taken facing north and there was no apparent patterning or trending in vegetation structure and diversity among each of the four cardinal directions. To arrive at a single foliage density value for each habitat, the proportion of vegetation cover was averaged across the three vertical profile boards for each sampling station, then the mean of the resulting 24 values was calculated.

Percent ground cover was assessed at each sampling station by the amount of vegetation (herbaceous, woody, and leaf litter) occupying a 1-m^2 quadrat against visible patches of ground (Brower et al. 1990). Canopy cover was estimated by the presence or absence (scored as 1 or 0, respectively) of vegetation viewed through a vertical ocular tube (James and Shugart 1970) at each sampling station. Average ground cover and canopy cover for each habitat was obtained by taking the mean of the 24 values of each metric.

The vegetation analysis was conducted once in March 1994 and once in August 1994, representing vegetation structure characteristic of the non-growing and growing seasons, respectively. Two months of the year, May and November, represent transitions between the growing and non-growing seasons and hence, characteristic vegetation density. For this study, vegetation variables for May were described by the August survey (i.e., high foliage density), and vegetation variables for November were described by the March survey (i.e., low foliage density).

Data analysis

Analyses of small mammal prey were based upon minimum number known alive (MNKA). This estimate was generated for each individual transect per month using Package C. M. R. (Le Boulengé 1987). The estimates then were averaged for the three transects to yield monthly small mammal species composition and abundance for each habitat.

To examine whether Coyotes shifted visitation rates in response to prey, it was necessary to determine whether spatial and temporal differences in prey abundances existed. Analysis of covariance (ANCOVA), conducted with SAS PROC GLM (SAS Institute Inc. 1990), was used to compare abundances of the most important prey species identified in Fermilab Coyote diets (Randa 1996). Specifically, analyses were conducted to test for significant fluctuations in prey abundances over time among each of the seven habitats. ANCOVA can be used to test for an interaction or heterogeneity of slopes (Littell et al. 1991) and was chosen because sampling units (i.e., habitats) were not replicated in space. Temporal changes of prey populations were indicated by crossing the categorical variable (i.e., prey abundances across habitats or prey abundances per habitat) with the continuous covariate (time). Traditional model building techniques were used (Box et al. 1978) in which non-significant, higher-order interactions were removed from the model. If no significant sources of variation were detected, the full model was reported. If significant interaction of variables occurred (i.e., heterogeneity of slopes), significance of main effects were inferred from the plotted data. Statistical inferences were based on type III

sum-of-squares and significance accepted at a = 0.05.

Multiple regression (SAS PROC REG; SAS Institute Inc. 1990) was used to evaluate the effect prey availability and vegetation structure had on Coyote visitation rates. Six independent variables were used in the model: the abundances of the three main prey genera, (1) *Microtus*, (2) *Peromyscus*, and (3) *Sylvilagus*, and the three vegetation variables, (4) vertical foliage density, (5) percent ground cover, and (6) canopy cover. Each observation in the multiple regression represented a single measure of the independent variable in one of the seven habitats during one of 15 months. Thus, there were 105 observations for each independent variable, or a total of 630 data points for the regression analysis. Data were logarithmic-transformed prior to analysis to help satisfy assumption of normality of the residuals. Collinearity diagnostics, such as tolerance values and variance inflation factors, indicated a lack of colinearity between the regressors, hence all independent variables were retained in the model.

Simple linear regression, performed with SAS PROC REG (SAS Institute Inc. 1990), was used to compare Coyote visitation rates against mice abundances in each of the two adjacent habitats, Tallgrass Prairie I and Oak Woods I. We performed a separate analysis for the response of Coyotes to prey increase following manipulation of the prey's food supply. Visitation rates of Coyotes around the experimental plots in Tallgrass Prairie II were analyzed using a one-way repeated measures analysis of variance (rmANOVA), with SAS PROC GLM (SAS Institute Inc. 1990). Inferences were based on Huynh-Feldt adjusted *P*-values for the rmANOVA.

Results

Among-habitat prey fluctuations

There was variation in spatial-temporal abundances of prey species (Figure 2) with significant species ($R^2 = 0.658$, $F_{[2, 264]} = 6.21$, $P = 0.002$), time ($F_{[1,264]} = 21.29$, $P \leq 0.001$), and time^2 ($F_{[1, 264]} = 14.17$, $P \leq 0.001$) effects, indicating that overall numbers of the three prey differed significantly. The significant time × species ($F_{[2, 264]} = 18.29$, $P \leq 0.001$) and time^2 × species ($F_{[1, 264]} = 11.74$, $P \leq 0.001$) interactions indicated that the rate at which prey species numbers changed also differed significantly. This was primarily due to the substantial increase in mice numbers (Figure 2). Furthermore, the significant time × habitat × species ($F_{[12, 264]} = 4.51$, $P \leq 0.001$) and time^2 × habitat × species ($F_{[12, 264]} = 4.84$, $P \leq 0.001$) interactions indicated that the differential rates in changes of numbers of species also changed among the different habitats. For example, the highest abundances of mice and voles occurred in November 1994 in the habitats Oak Woods I and Tallgrass Prairie I, respectively. The highest *Sylvilagus* abundance was documented in October 1994 in the Oldfield, with nearly equally high numbers recorded in July 1994 in the two prairie sites, probably following the weaning period of young rabbits in northern Illinois (Hoffmeister 1989). These abundance peaks are reflected in the quadratic function of the change in prey numbers over time.

Among-habitat Coyote visitation rates

Scent station visitation rates fluctuated widely among habitats and over time; no signs of Coyotes were found in Oak Woods II and the majority of tracks were recorded in the grassland habitats (Figure 3). Overall, the multiple regression of Coyote scent station visitation rates across Fermilab with the three main prey (Figure 4) and the three habitat structure variables (Figure 5) was significant ($R^2 = 0.241$, $F_{[6, 98]} = 4.40$, $P = 0.003$; Table 1). The unexplained variance in the model may be attributed to the observed variation in Coyote visitation (Figure 3) and 0 values recorded for prey abundances. Based upon results of the multiple regression, we conducted a separate analysis to discern whether the visitation rates in grasslands by Coyotes was due to prey (*Microtus*) or avoidance of wooded areas, from which voles were absent. Regression of scent station visitation rates with vole abundance, excluding data from the two oak woods, was not significant ($r^2 = 0.050$, $F_{[1, 73]} = 3.75$, $P = 0.057$).

In comparing Coyote visitation in the two adjacent habitats, Tallgrass Prairie I and Oak Woods I, scent station visitation rates, when averaged over the study period, were over three times greater in the prairie (0.035 ± 0.011 (mean ± SE); range 0.000—0.0645), than the woods (0.008, ± 0.003, range 0.000—0.0179; $t_{[28]} = 2.486$, $P = 0.026$). However, mice abundance was two times greater in the oak woods (4.7 individuals per transect ± 1.4, range 0.0—19.3) than the prairie (2.3 individuals per transect ± 0.6, range 0.3—8.0; $t_{[28]} = 1.637$, $P = 0.113$).

Within-habitat Coyote visitation rates

The fire in Tallgrass Prairie I did not result in a substantial increase in prey (Figure 2). However, the perturbation in Oak Woods I was followed by a considerable increase in mice abundance, enabling a within-habitat comparison to Coyote activity. Despite the high prey abundance, Coyote visitation rates were not significantly related to mice abundance ($r^2 = 0.158$, $F_{[1, 13]} = 1.03$, $P = 0.389$) in Oak Woods I.

Food supplementation in Tallgrass Prairie II resulted in an approximately three-fold increase in numbers of mice compared to the non-supplemented plots by February 1995 (Figure 6). Numbers subsequently declined until densities converged on the supplemented and non-supplemented plots in May 1995. Coyotes responded to the peak in mice densities with mean visitation around the food supplemented plots over five times greater than on non-supplemented plots in February 1995 (Figure 6). Coyote visitation around these plots in the ensuing three months reflected the trend in prey availability. The result was a significant food effect ($F_{[1, 2]} = 25.60$, $P = 0.037$), a significant time effect ($F_{[3, 6]} = 9.79$, $P = 0.013$), and a significant

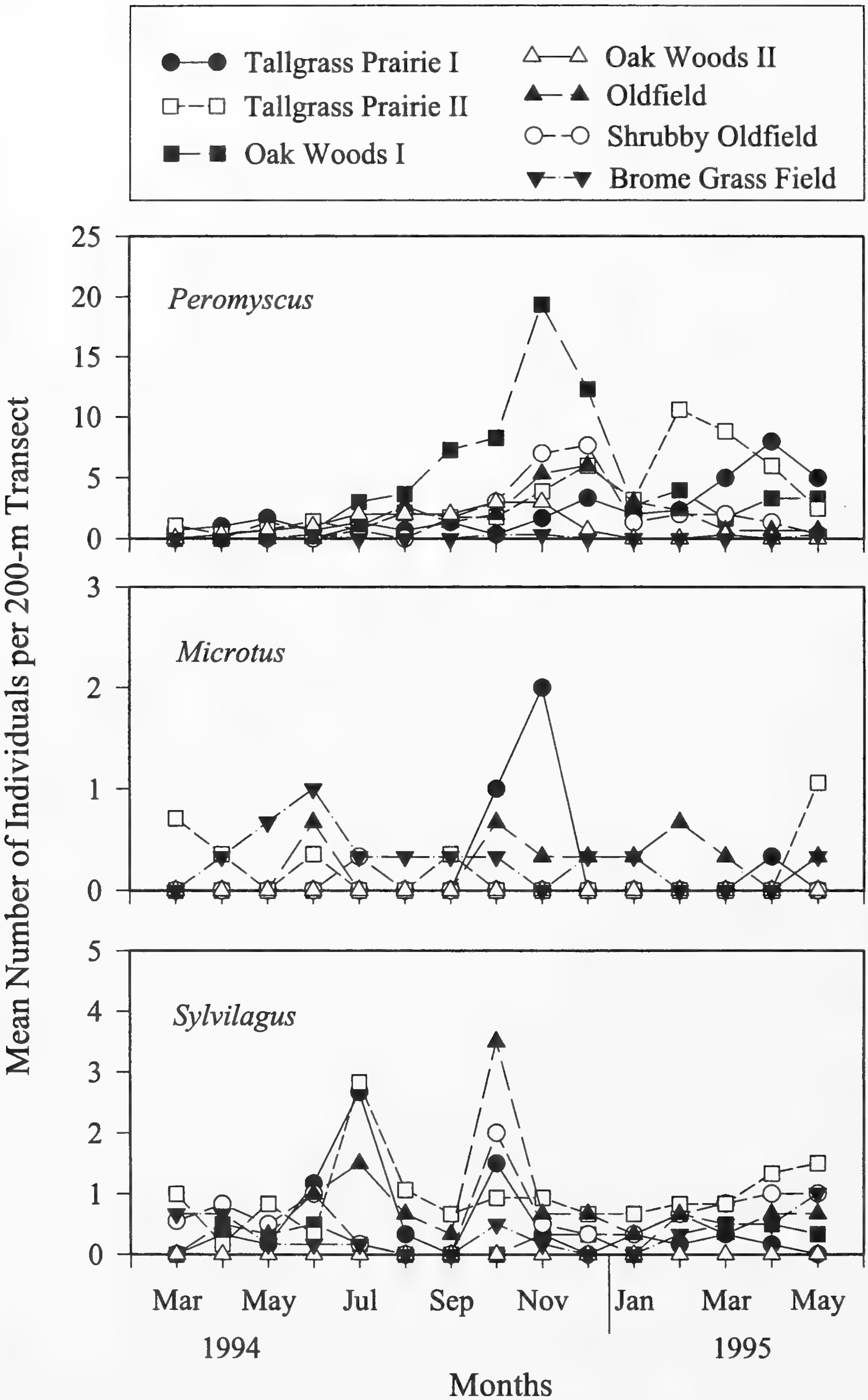

FIGURE 2. Abundances of the three main prey, *Peromyscus*, *Microtus*, and *Sylvilagus*, in each of the seven habitats over time.

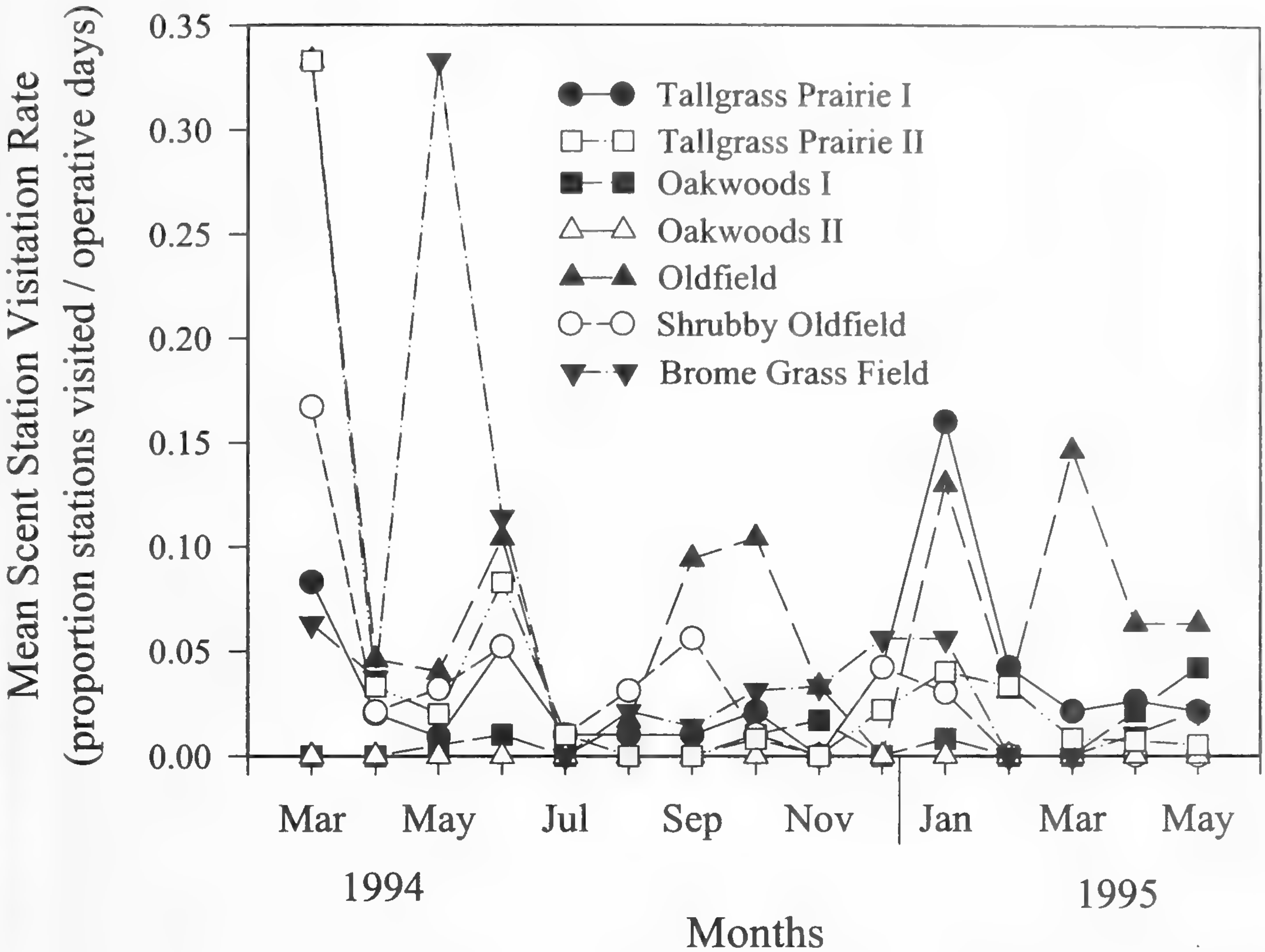

FIGURE 3. Habitat visitation of Coyotes, based upon monthly average scent station visitation rates, over time among the seven habitats.

visitation × time interaction ($F_{[3, 6]} = 10.32$, $P = 0.012$).

Vegetation characteristics of habitats

Of the three vegetation metrics collected, percent ground cover and canopy cover estimates were fairly consistent between the non-growing and growing seasons for each of the seven habitats sampled (Table 2). Vertical foliage density was greater in the growing season than the non-growing season for all habitats, reflecting the increase in above-ground plant biomass. Tallgrass Prairie I had the greatest difference in ground cover and foliage density between these seasons. This was due to the almost complete absence of litter and standing vegetation during the March survey, except for small clumps of tall grasses, a result of the previous fall's fire. There were similar trends of vegetation metrics among similar habitats. Vertical foliage density was greatest in the prairies compared to other habitats during the growing season, but was relatively low for the woods. The habitats dominated by grasses, the prairies and brome grass field, exhibited > 97% ground cover, exceeding estimates of other habitats. Canopy cover, as expected, was highest in the woods, with Oakwoods II having a denser overstory than Oakwoods I. The presence of canopy in the brome grass field was attributed to a few isolated trees located near the middle of the field, which was not expansive enough to markedly influence Coyote visitation.

Discussion

Coyote habitat visitation, measured through scent station visitation rates, fluctuated greatly over time, showing no clear temporal pattern among habitats. However, overall visitation indicated an extensive use of grasslands and avoidance of woodlands. Throughout the duration of the study, there was no evidence of Coyote tracks or scat in Oak Woods II, a mature woodlot with few gaps in its overstory, even though its entire western side bordered a tallgrass prairie, a habitat where Coyote scat and tracks in snow were observed. Oak Woods I also experienced relatively little Coyote visitation during most of the study. Although scent station transects were 50 m from habitat edges, all Coyote tracks were observed at the western end of the transects, which were closest to a grassy area near the woods. The shrubby oldfield experienced slightly more visitation, overall, than the woods, but tracks were found primarily at scent stations within open grassy areas and in the western por-

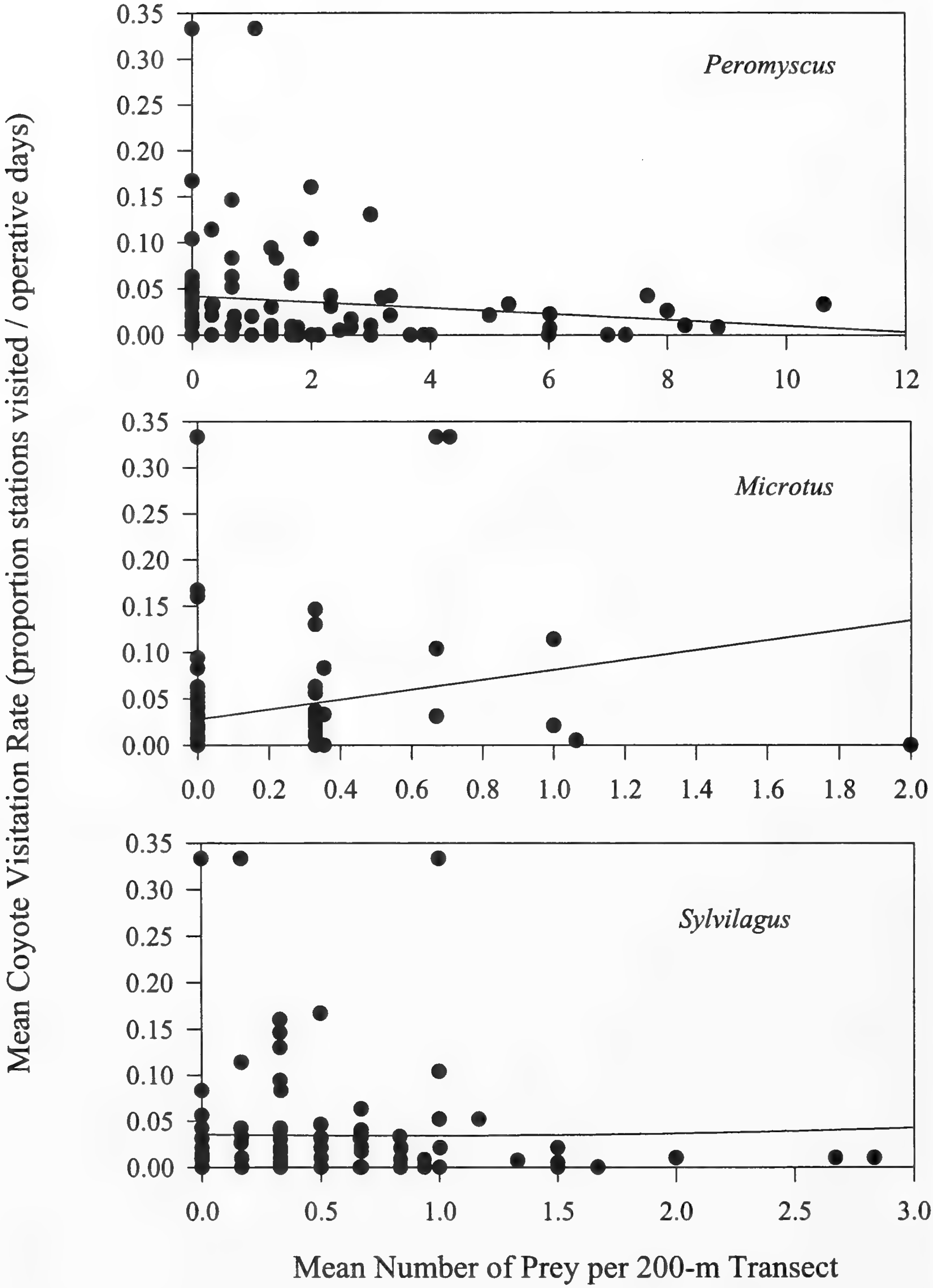

FIGURE 4. Partial regression plots for activity of Coyotes vs. abundances of each of the three main prey species. Each point represents a single observation recorded during 1 of 15 months in one of the seven habitats.

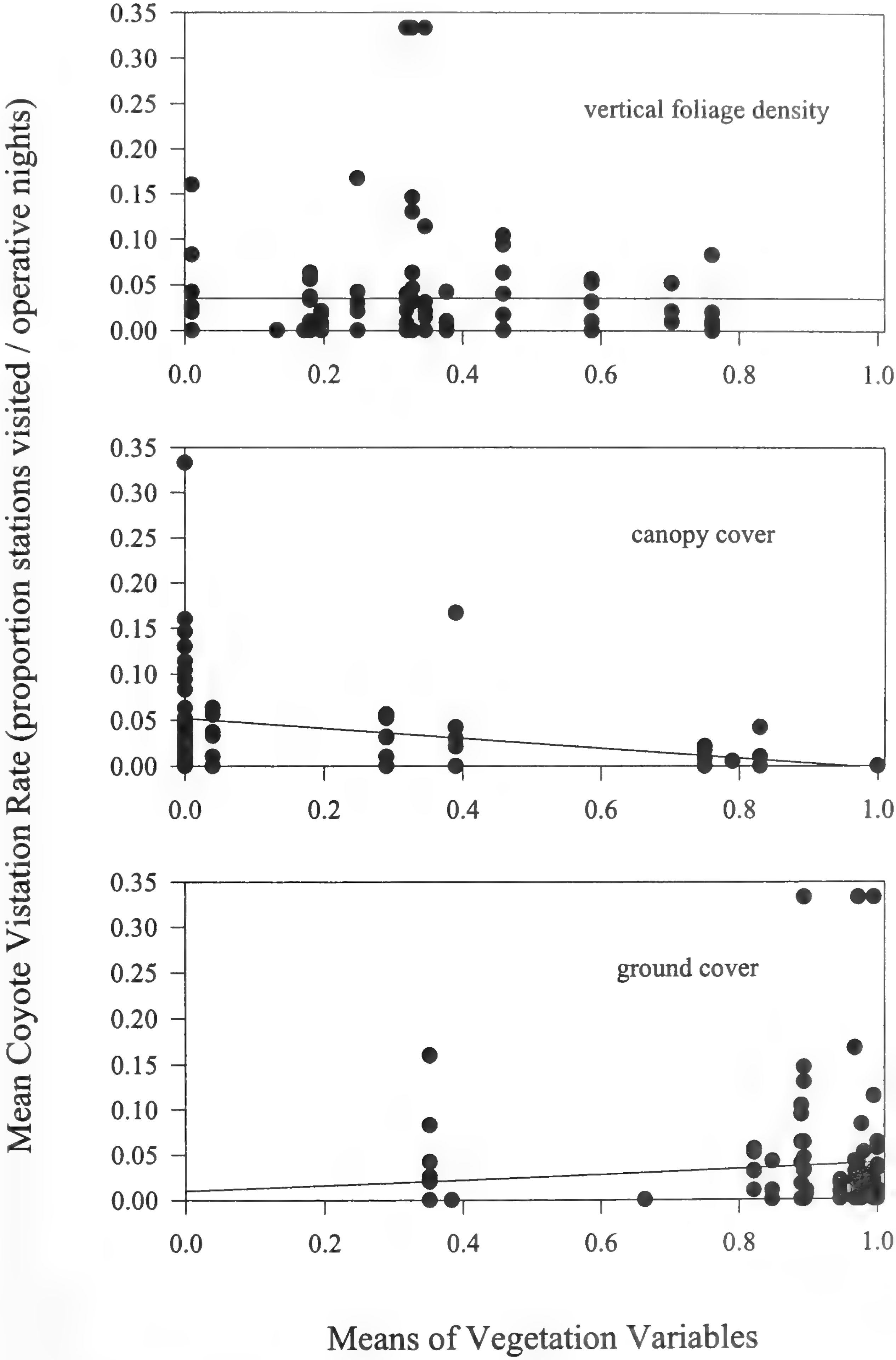

FIGURE 5. Partial regression plots for activity of Coyotes vs. each of the three vegetation variables. Each point represents a single observation recorded during 1 of 15 months in one of the seven habitats.

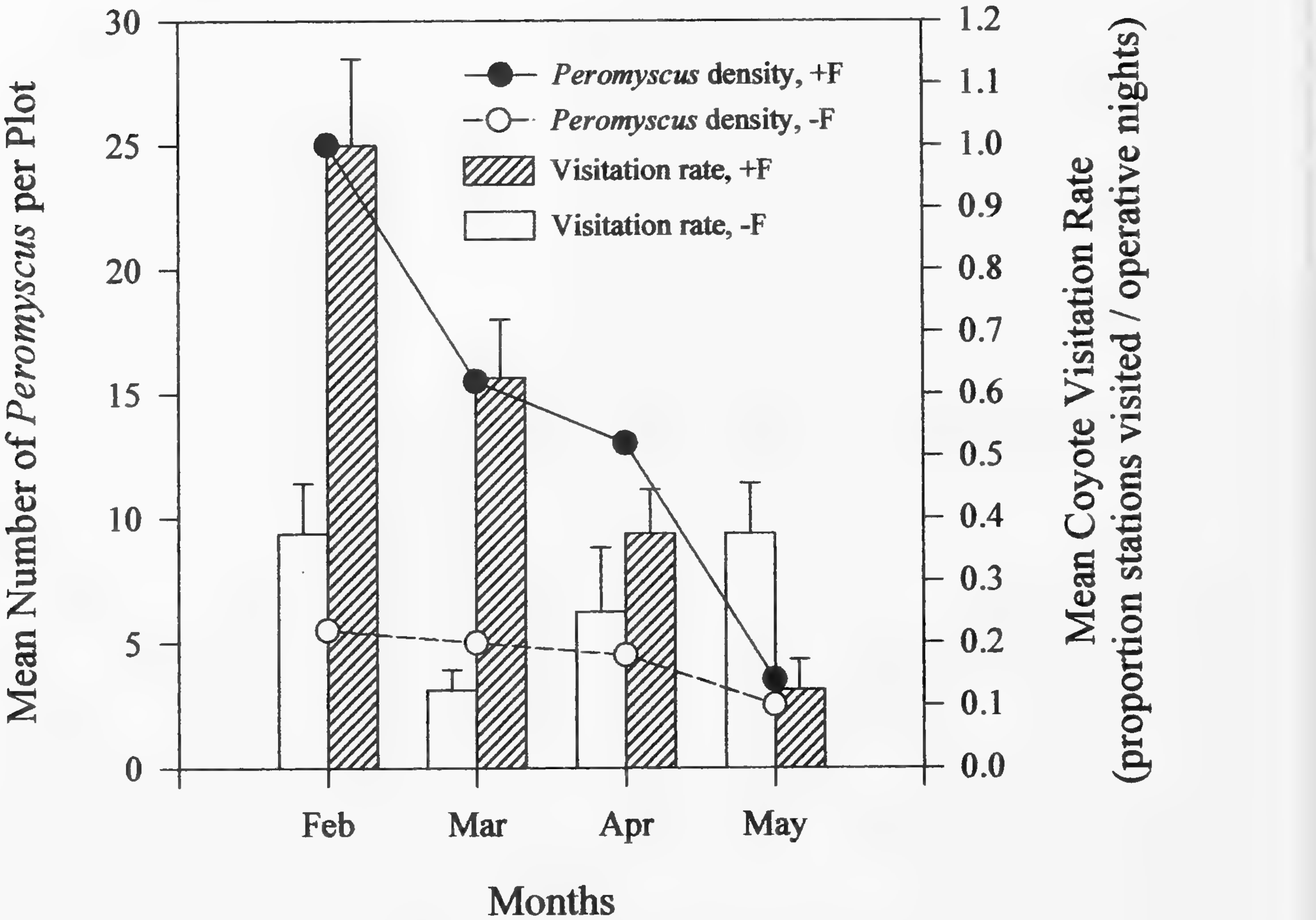

FIGURE 6. Comparison of activity of Coyotes and abundance of mice on food-supplemented (+F) and non-supplemented (-F) plots in Tallgrass Prairie II.

tion of this habitat which bordered a tallgrass prairie. These observations were supported by the significant negative relationship of canopy cover to Coyote visitation rates in the multiple regression analysis. Hence, Coyotes may move a limited distance into woods but tend to avoid core areas of heavily wooded habitats. This behavior was corroborated by a two-year radio telemetry study of Coyotes in northeastern Illinois (Roth et al. 1999*).

The multiple regression analysis also indicated scent station visitation rates by Coyotes were affected by abundance of voles, which was not found in the oak woods studied. However, a simple regression of Coyote visitation rates on vole abundance, excluding data from the two woods, did not reveal a significant relationship. Thus, it appeared that factors other than prey, such as vegetation structure, strongly influenced Coyote habitat visitation at Fermilab. In addition, overall visitation rates were not related to the abundance of Eastern Cottontails, which comprised the greatest biomass of prey in the Coyote diets (Randa 1996). This could possibly be attributed to the association of cottontail rabbits along habitat edges (Althoff et al. 1997; Mankin and Warner 1999; Smith and Livaitis 2000). Although some of the scent station transects were located within habitat areas where rabbits were found, Coyotes could have spent more time foraging for rabbits along these edges where transects were not located.

TABLE 1. Parameter estimates for independent variables used in the multiple regression analysis of Fermilab Coyote activities.

Variable	df	Regression coefficient	*P*
Intercept	1	0.0261	0.040
Peromyscus	1	-0.0082	0.192
Microtus	1	0.1192	0.006
Sylvilagus	1	-0.0169	0.359
Foliage Density	1	-0.0441	0.295
Canopy Cover	1	-0.0632	0.004
Ground Cover	1	0.0082	0.871

The selective use or visitation of grasslands by the Coyotes in this investigation may be associated with their historical range. Prior to European settlement, Coyotes occupied the southwest and central plains of the U. S. including grassland of southern Canada. Clearing of forests and extermination of the Grey Wolf (*Canis lupus*) facilitated the north- and eastward expansion of Coyotes. Coyotes moved northward along the Great Lakes, and colonized the northeastern U.S.

TABLE 2. Summary of vegetation characteristics for the seven different habitats sampled twice during 1995 at Fermilab; NG = non-growing season sampling, G = growing season sampling.

Habitat	Mean Vertical Foliage Density[a]		Mean Percent Ground Cover		Mean Canopy Cover[b]	
	NG	G	NG	G	NG	G
Tallgrass Prairie I	0.031	0.703	35.2	98.0	0.000	0.000
Tallgrass Prairie II	0.320	0.761	97.2	97.5	0.000	0.000
Oakwoods I	0.196	0.377	94.7	89.7	0.750	0.792
Oakwoods II	0.132	0.172	66.4	52.4	1.000	1.000
Oldfield	0.328	0.459	89.4	89.2	0.000	0.000
Shrubby Oldfield	0.248	0.587	96.7	89.5	0.389	0.340
Brome Grass Field	0.180	0.346	100.0	99.7	0.042	0.021

[a]Based upon the average proportion of three profile boards obscured by vegetation for 24 sampling stations per habitat.
[b]Based upon presence/absence scores (1/0 respectively) for 24 sampling stations per habitat.

(Richens and Hugie 1974) and the Midwest (Moore and Parker 1992) by the 1940s. Most Coyotes still inhabit deserts and grasslands, and those in regions with forests tend to use open, non-forested areas in a greater proportion than available (Todd et al. 1981; Toweill and Anthony 1988; Cypher 1991; Holzman et al. 1992; Murray et al. 1994; Kamler and Gipson 2000). Tracks of Coyotes observed in the snow at our study site indicated that grasslands, such as the brome grass field and tallgrass prairie, were occasionally traversed by Coyote tracks following a relatively straight path, reflecting non-foraging behavior. Hence, these open areas may not only serve as preferential foraging sites but as areas facilitating movement between habitats. A preferential use of grasslands may explain why chipmunks and tree squirrels, which were moderately common in the woodlands, were rarely detected in Coyote diets (Randa 1996).

Selective use of grasslands may have restricted the ability of Coyotes to respond spatially and temporally to localized patches of abundant prey within a habitat. In Fall 1994, when mice densities in Oak Woods I were more than twice the prey abundances at any other location, Coyote visitation did not increase significantly in that habitat. This discrepancy of prey abundance and coyote response in woodland corresponds with findings in southeastern Quebec (Richer et al. 2002). However, Coyotes demonstrated an ability to closely track prey within a grassland (Tallgrass Prairie II) as their visitation rates were correlated with experimentally manipulated abundant patches of mice. The high level and subsequent decline in Coyote visitation rates detected on scent stations around food-manipulated plots paralleled the change in mice densities. Hence, once mice decreased following a peak in densities on these plots, Coyote visitation rates likewise diminished. It was unlikely that Coyotes were responding to a novel item in the environment (such as the odor of the food) because supplementation had been initiated four months prior to the scent station monitoring. Because voles were not detected in this habitat during the experiment, a similar test of within-habitat Coyote response to abundant patches of this commonly consumed prey was not feasible. Yet, as with mice, Coyotes could have responded to isolated patches of voles within habitats throughout Fermilab, given that voles were still a major component of Coyote diets despite their low availability.

One limitation of the scent station transects was the difficulty in identifying Coyote responses to possible small, isolated patches of prey. Also, due to the large areas over which Coyotes may move, there was not sufficient separation to avoid visitation by the same individual between scent station transects (Diefenbach et al. 1994; Roughton and Sweeny 1982). However, by intensively sampling each habitat, these transects were effective in discerning overall trends (i.e., among-habitat comparisons) in Coyote visitation rates and relative habitat use; they were not intended to indicate finer-scale or localized responses (e.g., patch-level foraging) within the study site.

The results we obtained from both the experimental plots and scent station transects demonstrated that Coyotes exhibit variable responses to prey availability, depending upon habitat type. Reacting relatively quickly to a local increase in prey, as seen around the experimental plots in prairie, would enhance Coyote foraging efficiency. However, preferential use of open areas, as suggested by the transect data, may constrain foraging efficiency during periods of very low prey densities when alternative prey in woodlands is under-utilized. Hence, supporting Coyote populations near urbanized areas, as in northern Illinois, requires open land expanses such as grasslands to facilitate movements across large spatial extents within the landscape and to provide an adequate prey base.

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Presence of Cavities in Snags Retained in Forest Cutblocks: Do Management Policies Promote Species Retention?

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Tree cavities, which are frequently excavated by primary cavity nesters, are typically used by a number of avian and non-avian species and are thus important components in maintaining biodiversity in forest ecosystems. One way to provide these habitat opportunities in harvested areas is through the retention of snags. In this study, we assessed the habitat and snag characteristics that promote cavity excavation, using the presence of cavities to infer activity of primary cavity excavators. Snags retained closer to the forest/cutblock edge contained a greater density of cavities than trees further from edge. However, the proportion of cavities found within cutblocks declined at a more rapid rate with distance from edge than did those in adjacent forested stands. There was also a tendency for cavities to occur more frequently in trees that were at the advanced stages of decay. The results of our study suggest management for snags in harvest areas should include the retention of snags closer to the forest edge combined with incorporating trees showing signs of advanced decay.

Key Words: tree cavities, snags, forest edge, birds, mammals, reptiles, British Columbia.

Snags (standing dead trees) provide specialized habitat for many species, which in turn play an integral role in maintaining ecosystem functions (Machmer and Steeger 1995*). Approximately 16% of the indigenous birds, mammals, and reptiles in British Columbia depend to some extent on snags or cavities for reproduction, feeding, and shelter (Backhouse and Lousier 1991*). These dependent species then create habitat opportunities for other wildlife species, facilitate seed dispersal, increase soil aeration, accelerate organic decomposition, and can even aid in controlling forest pests (Machmer and Steeger 1995*). Although snags play an important role in the ecosystem, their removal has traditionally occurred in past forest management (ostensibly to reduce hazards – lightning attraction, falling snags, etc. – and foci of infection for healthy trees).

By retaining trees of varying ages, diameters, and decay classes in cutblocks, the vertical structure of vegetation, total percent vegetation, and percent deciduous cover increase. These changes can lead to greater species richness and diversity in both plant and mammal communities (Davis et al. 1999*). Population densities of cavity-nesting species are often limited by potential nest sites (Runde and Capen 1987), and intensive forest management that removes snags reduces their densities in managed stands compared to natural stands (Haapanen 1965; Pojar 1995).

Primary cavity nesters (those which excavate their own cavities, such as woodpeckers and some chickadees: Thomas et al. 1979) appear to prefer stands with a high number of snags (Zarnowitz and Manuwal 1985; Raphael and White 1984). As most primary cavity-nesting birds rarely occupy nests that they themselves have not excavated (Short 1979), suitable trees, including snags, must be available for excavation for nests or roosts. Snags offer softer excavating substrates as well as important foraging sites for these species. Conversion of natural forests into intensively managed stands which lack snags may, therefore, have long-term negative effects on the entire cavity-nesting populations, as secondary cavity-nesting species rely on primary excavators for cavity creation (Peterson and Grubb 1983).

Bodies that govern forestry practices recognize the importance of snags, and advocate the retention of a variety of tree species at various stages of decay in managed forests (e.g., Machmer and Steeger 1995*). In an effort to reduce the impact of large openings created by cutblocks, some forest companies retain windfirm deciduous trees and advanced regeneration that fall below utilization standards to aid in maintaining structural diversity in cutblocks. This limits the distance wildlife must travel through the cutblock without vegetative cover. The traditional paradigm has been that efforts such as these will be sufficient to maintain wildlife and biodiversity throughout managed forests.

One aspect of snag retention policy that has been overlooked, however, is the behavioral characteristics of primary cavity-nesting species that may deter members of this guild from occupying trees left specifically for their use. Many forest birds avoid areas outside forested cover (Hegner 1985; Desrochers and Hannon

1997), as open spaces leave these species susceptible to hawk and falcon predation (Corral 1989). Several studies have shown that many forest dwelling species are reluctant to cross gaps between fragmented forested areas (Lens and Dhondt 1994; Desrochers and Hannon 1997). Desrochers and Hannon (1997) found that forest birds were three times less likely to cross gaps 70 metres wide, and eight times less likely to cross gaps 100 metres wide compared to similar distances within the forest. Machtans et al. (1996) also found that movement rates of forest birds across cutblocks were significantly lower than movement rates within the forest. Instead, forest birds preferred to travel much greater distances through corridors, rather than crossing narrow gaps (Desrochers and Hannon 1997).

The avoidance of open spaces indicated that forest birds – with the majority of those studied belonging to the cavity-nesting guild – have fewer habitat opportunities as the landscape becomes increasingly fragmented. Although retained snags may be scattered throughout cutblocks to provide nest sites, the gap between the forest edge and the snag may be too substantial for birds to cross. In turn, the number of cavity-nesting birds may decline with increased distance into cutblocks as compared to the surrounding forest.

In this study, we documented the presence of cavities in retained snags within forest cutblocks as a measure of use by cavity-excavating species, and compared this to similar trees found within the surrounding forest. If primary cavity nesting species avoid openings in forest cover, we predict fewer cavities as one travels further from the forest edge into cutblocks. By assessing attributes of cavity-possessing trees, we attempt to identify which tree characteristics and tree species cavity nesting birds tend to utilize. Our aim is to provide well-substantiated recommendations towards the placement and creation of retained snags within cutblocks that maximize potential usage by cavity nesting species.

Methods

Study Area

This study was carried out from 30 September to 5 November 2000, approximately 30 kilometers west of Prince George, British Columbia (53°36'35"N, 122°57'29"W). All samples were located within the Sub-Boreal Spruce biogeoclimatic zone, which covers much of the central interior of British Columbia (MacKinnon et al. 1992). The study area was primarily composed of coniferous and mixedwood forests, with species including Lodgepole Pine (*Pinus contorta* var. *latifolia*), hybrid White Spruce (*Picea glauca* × *engelmannii*), Sub-alpine Fir (*Abies lasiocarpa*), Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), Trembling Aspen (*Populus tremuloides*), Black Cottonwood (*Populus balsamifera* ssp. *trichocarpa)* and Paper Birch (*Betula papyrifera*). Harvested areas are typically replanted with Lodgepole Pine, with a small component of hybrid White Spruce on moister sites.

Sampling Procedure

We randomly selected eight cutblocks for the survey from a Forest Development Map. The cutblocks ranged in age from 3 to 10 years post-harvest, and from 30 to 60 hectares in size. A line-transect method of sampling was used. In this method, all retained snags falling within 5 metres of each side of the transect were measured. We ran transects on a bearing perpendicular to the forest edge, with a random point of commencement along the edge being selected from the Forest Development map. Measurements were carried out until the centreline of the cutblock was reached and at least 20 snags were encountered. In one case, the cutblock contained only 17 retained snags. Due to the minimal number of retention trees present, the line-transect method would have been relatively ineffective; therefore; all retention trees in the cutblock were measured.

Snags were defined as any dead, standing tree (Smith et al. 1997: 489). We recorded all cavities that were either actively excavated or were natural cavities of similar size, which displayed signs of active use (e.g., modification to the cavity, presence of feathers in entrance, etc.). Cavities were only recorded if they had a minimum diameter of 3.5 cm, as the cavity had to be large enough for use by a small bird or mammal. However, as our study was looking for evidence of use of the trees rather than specifically focusing on nesting, we did not distinguish between cavities used for roosting versus those where nesting had occurred. For each snag encountered along the transect, we recorded several attributes: tree species, height, diameter at breast height (DBH, measured at 1.3 m from the base of the tree), decay class, number of cavities, distance from the nearest timber edge, percent overhead cover, and the number of snags and live trees within an 11.28 m radius around the trees. Only trees greater than 10 centimeters DBH were recorded, as this reduced the chance of incorporating regeneration into the study. Decay class was determined using a six-step hardwood classification scheme combined with a corresponding nine-step coniferous classification scheme (Ministry of Forests 2000*).

Similar transects were placed in the adjacent forested stands running perpendicular to the edge. In order to measure a similar number of trees over the same distance in both habitat types, every third tree classified as decay class 2 or greater was measured. In order to determine the initial tree for measurement along each transect, a coin toss was completed to decide if the first or second tree should be measured. For each tree encountered along transects in forested stands, the same attributes were measured as those collected for cutblock sampling.

Statistical Analysis

A multiple regression was used to determine if the habitat (forest or cutblock) and distance from the forest edge influenced the proportion of cavities found (SYSTAT 9.01). To compare the distribution of tree

types across the two habitats, we employed a Chi-square and used a Mann-Whitney U test to compare the frequency of decay classes of trees between cutblocks and forested stands.

To determine which characteristics tended to predict the presence of cavities in wildlife trees, we conducted a Principal Component Analysis (PCA) on trees in the forested stands. As the forest stands constitute the natural habitat of many of the primary cavity-nesting species, determining the characteristics of cavity-bearing trees in these areas may give insight into which types of wildlife trees are important to retain in cutblocks. The following characteristics of the focal tree and the immediate area were subjected to PCA: height, diameter, and decay class of the focal tree, along with the total number of trees, number of live trees, number of snags, and percent overhead cover within the 11.28 metre radius plot. A linear regression was used to compare the number of tree cavities against the PCA factor scores. The PCA was carried out in SYSTAT 9.01 using Varimax rotation.

Two retention trees measured had extremely high numbers of cavities and were identified during initial analysis as significant outliers in the data set (Durbin-Watson D Statistic = 1.984, $P < 0.01$). These were excluded from subsequent analysis.

Results

In total, 185 trees were measured at our eight sampling sites; 94 trees within cutblocks and 91 trees within forested stands. We found 46 cavity-bearing trees, containing a total of 67 cavities. Of the 46 trees containing cavities, 29 were deciduous while the remaining 17 were conifers.

A greater proportion of deciduous trees contained cavities compared to coniferous species. Species of willow had the highest proportion of cavities, with two of the three trees observed containing cavities. Trembling aspen was found to have the second highest frequency of cavities with 17 of the 62 trees observed containing cavities. A breakdown of the number of cavities recorded by species is given in Table 1.

The species composition of trees differed between the two habitats ($\chi^2 = 76.6$, df = 6, $p< 0.01$ – Figure 1). Snags in cutblocks were primarily deciduous species; although these trees were also present in forested stands, the latter stands had a proportionately higher coniferous component.

Distance From Edge and Cavity Abundance

Distance from forest edge and stand type (cutblock or forest) both had a significant effect on the number of cavities found (multiple regression: $r^2=0.051$, $F_{(2, 180)} = 4.857$, $p = 0.009$). The further a tree was located from the forest-cutblock edge, the lower the frequency of cavities ($p = 0.027$). There was also a significant effect between the stand types, as more cavities were found in the forest than were found in the cutblock ($p = 0.020$). In the forest stands, the decline in number of cavities found with distance from the edge was not as dramatic as that seen in cutblocks (Figure 2a and b).

Stand Characteristics Associated with Snags

The principal component analysis identified two factors that accounted for 56.2% of the total variance among retained snags (Table 2). Principal component one (PC 1) accounted for 31.2% of the variance, with strong positive weightings for a high number of total trees and a high number of live trees within an 11.3 m radius plot. As a result, PC 1 can be considered a measure of the density of trees surrounding the snag.

Principal component two (PC 2) accounted for 25.0% of the total variance, with a strong positive weighting for decay class and a strong negative weighting for tree height. PC 2 indicates trees at the latter stages of the decay process, as tree height frequently decreases

TABLE 1. A breakdown of the number of cavities by tree species.

Tree Species	Number of trees observed	Total number of trees with cavities	Percentage of trees with cavities	Total number of cavities
Trembling Aspen *Populus tremuloides*	62	17	27.4	32
Lodgepole Pine *Pinus contorta* var. *latifolia*	52	13	25.0	14
Paper Birch *Betula papyrifera*	32	8	25.0	10
Hybrid Spruce *Picea glauca × engelmannii*	24	4	16.7	5
Willow *Salix* sp.	3	2	66.7	3
Black Cottonwood *Populus balsamifera* ssp. *trichocarpa*	8	2	25.0	3
Douglas Fir *Pseudotsuga menziesii glauca*	4	0	0	0
Total (Average)	185	46	(24.9)	67

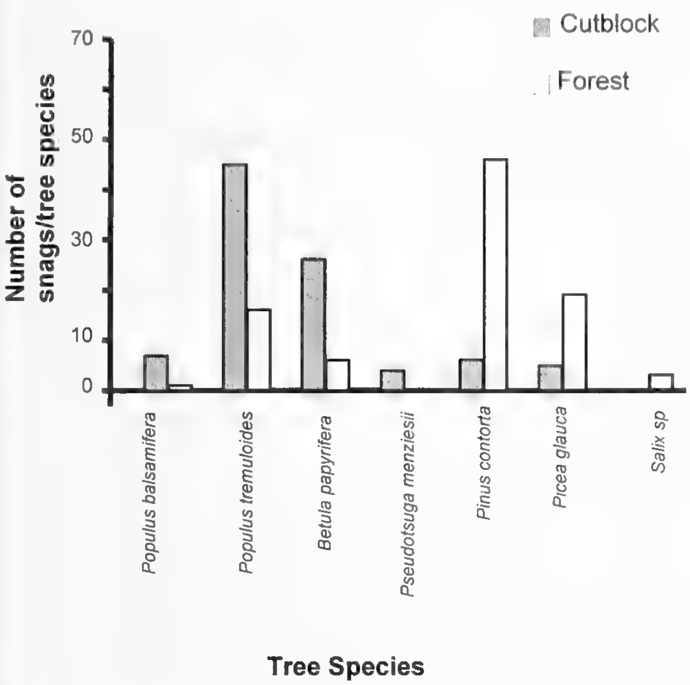

FIGURE 1. Distribution of sampled snags within cutblocks versus surrounding forest stands.

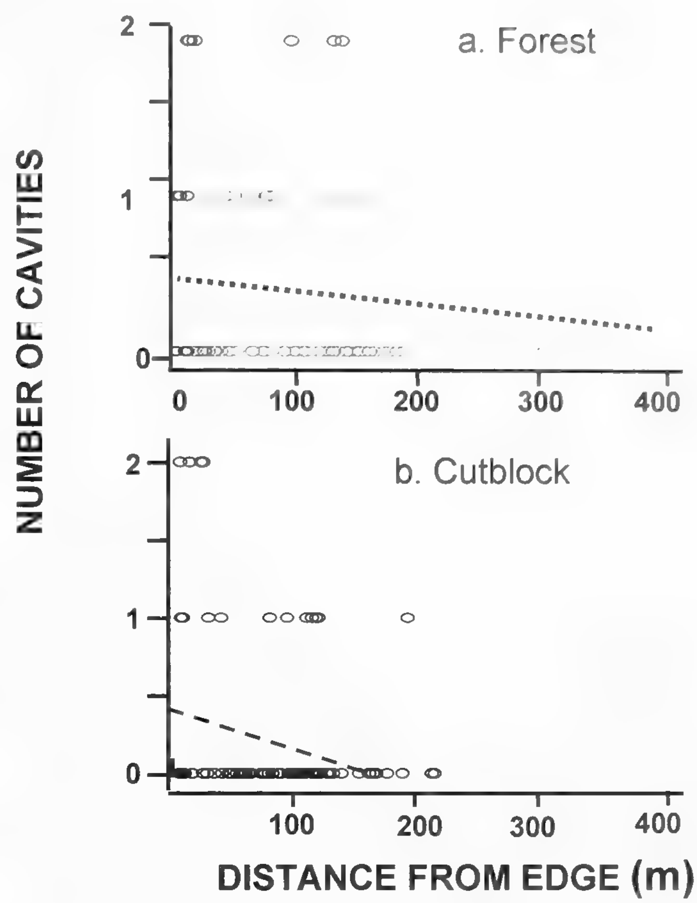

FIGURE 2. Regressions of distance from forest edge against the number of cavities located in trees in forested stands (a – shown by a dotted line) and cutblocks (b – shown by dashed line).

as the tree reaches the higher decay classes (Towers et al. 1992).

Response of Cavity Nesters to Stand Characteristics

There was no significant relationship between the number of cavities found and PC 1 (regression: $r^2 = 0.003$, $F_{(1,90)} = 0.281$, $p = 0.60$). There was, however, a significant effect between the number of cavities being found and PC 2 (regression: $r^2 = 0.092$, $F_{(1,90)} = 9.13$, $p = 0.003$) indicating that more cavities occurred in trees with a higher amount of decay.

On average, the snags retained in clearcuts had less decay than the comparison cohort of trees in the forested areas (MWU: $U = 2918.5$, $n = 93, 91$, $p<0.01$).

Table 2. Principal component analysis of stand characteristics in forest stands. The first two Principal Components account for greater than 50% of the total variance among stand attributes; therefore only these two factors were considered in subsequent analysis. Variables that were within 10% of the highest loading were considered to be strong weightings, and are shown in bold.

Variable	PC 1 (clustering of retention trees)	PC 2 (decay stage)
Tree Diameter	-0.407	-0.395
Tree Height	0.272	**-0.714**
Decay Class	-0.353	**0.738**
Total Number of Trees	**0.947**	0.212
Number of Live Trees	**0.956**	0.115
Number of Snags	0.000	0.392
Percent Overhead Cover	-0.029	0.573
Percent of Total Variance explained by each Factor	31.15	25.02

Discussion

Edge Effects on Cavity-nesting Birds

The number of cavities located within both cutblocks and forested stands were related to the distance from forest edge. Trees located farther from the forest edge had a tendency to contain fewer cavities than trees located closer to the forest edge. There was also a greater abundance of cavities located within forested stands than within cutblocks. Yet, although the number of cavities declined rapidly as the distance from cutblock edge increased, the equivalent decline was less rapid in forested stands. This suggests that retained snags farther from forest cover were underutilized by cavity-excavating species.

One possible bias in our results might arise if cavities found in the cutblocks existed prior to harvesting. Although we focused on measuring cavities that appeared to be recently used/excavated, it was occasionally difficult to distinguish between recently excavated cavities and cavities that may have existed prior to logging. However, if some of the cavities existed prior to harvest our results would over-estimate the level of activity of cavity-excavating species in cutblocks, thus minimizing the perceived effect of harvesting on cavity nesters. Despite the possible bias of including pre-existing cavities, we continued to see a reduced number of

cavities in clearcuts. Thus, the magnitude of the effect we report may be even more pronounced between the different habitats.

Several possible explanations may exist for the lower densities of cavities within cutblocks. The reduced number of cavities in cutblock trees could be due to the reluctance of many species of forest birds to cross large openings. Desrochers and Hannon (1997) found that forest birds were extremely vulnerable to raptors when they fly in the open, and thus were hesitant to enter such areas. Secondly, the lower densities of tree cavities within cutblocks could be due to the retention of trees with minimal habitat value for cavity nesting species. Cavity nesters tended to prefer deciduous tree species, as a greater number of cavities were found in these trees than in coniferous tree species. In conifer-dominated ecosystems, such as boreal and sub-boreal forests, deciduous trees often have greater heartwood decay than conifers and may be preferred as nesting substrate once the trees become snags, resulting in increased avian diversity (Martin and Eadie 1999). Yet, deciduous species accounted for a larger number of snags in the cutblocks than the forests in our study, and there was still a lower number of cavities in cutblocks than neighboring forests. While the retention of these deciduous snags likely increases diversity along the edge, the reluctance of birds to venture into cutblocks may have a larger influence on snag use farther from forest cover.

The highest density of cavities was located within 100 metres of the forest edge. Higher bird populations located at the forest edge compared to the community interiors has also been found in several other studies (see Gates and Gysel 1978; McElveen 1979; and Streikle and Dickson 1980). Several theories exist to support such behaviour. Marcot (1983) suggested that many cavity-nesting species nest in the nearby forest, whereas they use cutblocks for foraging, resulting in higher densities of birds seen along the community edge. Both the Northern Flicker (*Colaptes auratus*) and the Downy Woodpecker (*Picoides pubescens*), primary cavity excavators, prefer to nest in old trees near openings or on the edge of the forest (Ehrlich et al. 1988). Our results suggest this pattern may occur within our study area. Cavity density was highest at edges, but remained high for greater distances into forests than into cutblocks. Thus, marginal species attracted to edges may prefer to either nest on the edge or penetrate into the forest, rather than establish nests in snags retained in the cutblocks. Coupled with non-edge species, this would create the pattern of greater cavity abundance in forested sites.

Tree Attributes and Cavity Abundance

Within forested stands, cavities were found more often in trees that contained a combination of high levels of decay and shorter tree height. Decayed portions of the tree allow for easier cavity excavation for weaker cavity excavators, and the bark cover retains moisture and warmth as well as providing protection from predators (Runde and Capen 1987). Decayed portions of the tree also provide valuable foraging habitat as they often contain high levels of beetle larvae, carpenter ants, and termite activity, all of which act as food resources for woodpeckers (Mannan et al. 1980). This too may explain the lower use of cavities in cutblocks, as trees retained in these areas had less decay compared to trees sampled randomly in the surrounding forests. This is likely the result of trees with greater decay being removed as potential hazards during forestry operations. Retention of these higher decay class trees, however, may be valuable in future planning. It is important to retain trees at a variety of levels of decay, as the nesting success of some primary cavity excavators is higher in snags in the 2-3 decay class range (Fort and Otter 2004).

Management Implications and Recommendations

Primary cavity nesters require specific habitat conditions (Conner et al. 1976), and without these conditions territory selection and reproductive success may be compromised (Kilham 1966). As a result, population densities of both primary and secondary cavity nesters may decline.

In order to maintain the population levels of primary cavity-excavators it is essential to provide adequate habitat through efficient forest management. Snags and snag patches may be most efficient if they are placed within 100 metres of the forest edge, as this limits susceptibility of forest-dwelling birds to predators. The retention of trees for the purpose of managing cavity nesting birds should focus on maintaining a high deciduous component within the stand. Cavity nesters tended to select a high level of deciduous trees for cavity excavation throughout this study. Maintaining a variety of deciduous and coniferous trees within cutblocks could prove to be beneficial for population densities of cavity nesters, as well as many other species of snag users.

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Summer Diet of Two White-tailed Deer, *Odocoileus virginianus*, Populations Living at Low and High Density in Southern Québec

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We investigated summer diets of two White-tailed Deer (*Odocoileus virginianus*) populations through rumen content analyses. Samples from 93 deer were collected in a low density, LD (1 deer/km^2) and a high density, HD (14 deer/km^2) area of southern Québec during the growing seasons of 1997 and 1998. Availability of preferred forage in forests was greater in LD than in HD, whereas agriculture covered a larger proportion of the area in HD than LD. Rumen composition differed between the two populations. Deer from HD consumed less forbs and leaves of shrubs and trees than did LD deer, whereas they consumed more fruits, grasses and farm crops. The rarity in HD rumens of food items common in LD, as well as in many parts of the White-tailed Deer range (i.e., Lilliacae), indicated that deer could not compensate for the rarity of preferred forest forage by increasing foraging time and had to feed on cultivated crops. Rumen contents of LD deer had a higher level of cell solubles and lignin, which reflected their greater reliance on quality forage growing in forests. Feeding habits and forage quality can explain why deer body size decreased in HD between the 1970s and 1990s whereas LD deer remained large.

Key Words: White-tailed Deer, *Odocoileus virginianus*, diet, density, forest, agriculture, plant, Québec, Canada

Nous avons examiné le régime alimentaire estival de deux populations de cerf de Virginie (*Odocoileus virginianus*) par l'analyse du contenu des rumens. Des échantillons ont été prélevés sur 93 cerfs provenant d'un secteur à faible densité de cerfs, LD, (1 cerf/km^2) et d'un secteur à haute densité, HD, (14 cerfs/km^2) du sud du Québec durant la saison de croissance des végétaux de 1997 et 1998. La disponibilité des aliments forestiers préférés des cerfs était plus grande dans LD que dans HD alors que la proportion du territoire agricole était supérieure dans HD. La composition des rumens des cerfs de chacune des régions différait. Les cerfs de HD ont consommé de moins grandes proportions de plantes herbacées et de feuilles d'arbustes et d'arbres que ceux du secteur LD, mais de plus grandes proportions de fruits, de graminées et de plantes agricoles. La rareté dans les rumens du secteur HD d'aliments communs dans ceux du secteur LD et dans plusieurs autres régions de l'aire de répartition du cerf (e.g., Lilliacae), indique que les cerfs du secteur HD ne pouvaient compenser pour la rareté de leurs aliments préférés par un accroissement de la durée de la quête alimentaire, et qu'ils devaient consommer des plantes agricoles. Les cerfs de LD ont mangé des aliments contenant plus de solubles cellulaires et de lignine que ceux de HD, ce qui reflète une consommation de plantes forestières de bonne qualité. Le régime alimentaire et la qualité de la nourriture peuvent expliquer pourquoi la taille des cerfs de HD a diminué entre les années 1970 et 1990 alors que celle des cerfs de LD est demeurée grande.

White-tailed Deer, *Odocoileus virginianus*, are selective feeders and although they ingest a wide variety of plants, only a few taxa make up large proportions of their diet (Johnson et al. 1995; Healy 1971; Korschgen et al. 1980; McCaffery et al. 1974). Plant phenology influences their diet; forbs and leaves of deciduous woody plants are common food items in spring and summer, and fruits become major components of the autumn diet. White-tailed Deer also consume mushrooms in natural ecosystems (Crawford 1982; Johnson et al. 1995; Korschgen et al. 1980; Short 1971; Skinner and Telfer 1974), whereas farm crops can be major food sources in agricultural landscapes (Nixon et al. 1991). During winter, White-tailed Deer switch to twigs of both deciduous and evergreen woody plants and, where snow cover allows access, they also use grasses and farm crops left after harvest (Johnson et al. 1995; McCaffery et al. 1974; McCullough 1985; Nixon et al. 1991; Skinner and Telfer 1974).

Forage competition results in consumption of food of reduced quality or availability, which lengthens ingestion and digestion. At high density, forage competition can modify feeding habits of ungulates, in particular for small, selective species (Kie and Bowyer 1999) and reduce body size in cervids (Ashley et al. 1998; Crête et al. 1993; Hjeljord and Histol 1999; Lesage et al. 2001). In mid-latitude deer, forage competition during the growing season likely determines adult body

size because growth and replenishment of body reserves occur during this period of the year (Hjeljord and Histol 1999; Lesage et al. 2001; Boucher 2004).

On the south shore of the St. Lawrence River in Québec, the carrying capacity of the deer range decreases northward because suitable forest stands for wintering become increasingly rare with increasing winter severity (Boucher 2004). Density averaged ≈1 deer/ km^2 in northernmost hunting zones of Québec whereas it locally exceeded 30 deer/km^2 in southern zones after populations erupted due to mild winters and a conservative hunting regime. Forage competition in winter regulates deer numbers in the absence of Grey Wolves (*Canis lupus*) and under conservative hunting regime (Dumont et al. 2000), but agriculture can help deer to survive winter by providing some food during the dormant season (Rouleau et al. 2002a). In recent decades, browsing pressure exhibited a pronounced gradient on the south shore of the St. Lawrence River, which resulted in a scarcity of preferred summer forage in southern vs. northern zones (Rouleau et al. 2002a). Vegetation sampling throughout the deer range in Québec showed a general pattern of negative relationship between deer density on one hand, and preferred forest forage and deer size on the other (Boucher 2004). Deer living at low density tended to avoid cultivated fields (Lesage et al. 2002) and reached the largest size among Québec deer (Lesage et al. 2001).

We studied the summer feeding habits of White-tailed Deer in two areas which differed markedly with respect to deer density, forage availability, importance of agriculture, and winter severity. The objective of this study was to compare composition and quality of summer diets of these two White-tailed Deer populations. We anticipated that preferred forage of deer living at low density would be less abundant in rumens of deer living at high density and that the low density population would consume forage of higher quality due to relaxed forage competition during summer.

Study Area

Samples were collected in a low-density area (LD) and a high-density area (HD) (Figure 1). The LD study area is located in a transition zone between northern hardwood forests and boreal forests (Rowe 1972*). Among trees, Balsam Fir (*Abies balsamea*), White Spruce (*Picea glauca*), Eastern White Cedar (*Thuja occidentalis*), Trembling Aspen (*Populus tremuloides*), and Yellow Birch (*Betula alleghaniensis*) dominate (Lamoureux 1994*). Commercial logging has been intensive in this region and the spruce budworm (*Choristoneura fumiferana*) adversely impacted fir and spruce stands in the late 1970s. Agriculture represents about 10% of the land use in the study area and hay; alfalfa (*Medicago sativa*), cultivated and upgraded pastures, oat (*Avena sativa*), and barley (*Hordeum vulgare*) cover most cultivated fields. The growing season averages 160 days (Wilson 1971*) and snow cover often exceeds 50 cm for more than 50 days. Deer density was estimated through double-count aerial surveys (Potvin et al. 1992) and averaged 1.1 deer/km^2 in summer 1998 (Lamoureux and Pelletier 2000*).

Northern hardwood forests cover most of the HD study area. Commercial logging has affected mainly coniferous stands on small areas due to land ownership and forest composition (Gosselin 1994*). Most common tree species include Sugar Maple (*Acer saccharum*), Red Maple (*Acer rubrum*), Yellow Birch, American Beech (*Fagus grandifolia*), White Ash (*Fraxinus americana*), Balsam Fir, Hemlock (*Tsuga canadensis*), Eastern White Cedar, and White Spruce. Forests have been cleared for agriculture throughout the region. They have progressively grown back on abandoned farms; and introduced plants such as apple trees (*Malus pumila*) are common in today's forests. Agriculture now covers about 23% of the area. Hay, corn (*Zea mays*), uncultivated pastures, cultivated and upgraded pastures, and alfalfa dominate cultivated fields. The growing season averages 190 days and snow cover rarely exceeds 50 cm. Deer density averaged 14.1 deer/km^2 in summer 1996 (Dicaire 1999*); locally it may exceed 30 deer/km^2.

Methods

Forage composition – We collected rumen samples from road kills during the growing season (13 May – 2 November 1997 and 1998). Rumen samples were generally collected within 3 days after collision (maximum 5 days), provided that identifiable forage fragments remained. Rumen content was hand mixed and two one-litre samples were extracted. The first litre was frozen for forage identification and the other preserved in 4% formalin for chemical analysis. At the laboratory, frozen samples were thawed and washed through a 7.9 mm and a 4.0 mm mesh size sieve (Crête et al. 1990; Gauthier et al. 1989). About 50 ml of the particles kept by the 4.0 mm sieve were spread into a 20 × 50 cm sampling tray (Chamrad and Box 1964) and covered with 1 cm of water. One hundred particles were systematically selected by point sampling (Crête et al. 1990) and identified through macroscopic and microscopic (10 – 25×) examination to family, genus or species whenever possible. Reference plant samples served for comparison during the identification process. Samples were grouped by taxon and their volume measured by water displacement (±0.25 mL). Plants were grouped into eight categories for statistical analyses: graminoids (Graminae and Cyperacae), farm crops, forbs (without flowers or fruits), leaves of shrubs and trees, wild flowers, wild fruits, mushrooms, and unknown.

Forage quality – We reasoned that rumens of deer consuming poor quality forage would contain fewer nutrients with rapid assimilation and more nutrients with slow digestibility than counterparts feeding on

better quality forage. Poor quality forage could also include more secondary compounds slowing or inhibiting digestion. We measured cell solubles, lignin, and phenolics as proxy for rapid digestibility, slow digestibility and defensive compounds. We also determined nitrogen (N) content because it proved to be a good indicator of summer diet quality in Caribou (*Rangifer tarandus*) (Crête et al. 1990). We used the detergent method (Gauthier et al. 1989; Goering and Van Soest 1970) to measure cell solubles (1-NDF) and acid detergent lignin (ADL) (Mould and Robbins 1982). Cell solubles are highly digestible whereas lignin is largely not (Robbins 1993: 251, 294). Total nitrogen content (N) was measured with an automated Macro-Kjeldahl analyzer and total phenolic content was determined by a calorimetric method using the Folin-Ciocalteu reagent (Marigo 1973; Sauvesry et al. 1991). Proteins are also highly digestible (Robbins 1993: 294) whereas phenolics includes 8000 substances, of which tannins are known for reducing protein digestion (Robbins 1993: 300). Some samples could not be analysed due to inadequate quantities. All analyses were duplicated or triplicated whenever a difference of more than 5% was found between the first two measurements. The average of the two closest estimates served as results.

Forage availability – We estimated forage availability during a companion study in the same study areas (Rouleau et al. 2002a). We measured forage biomass between the ground and 1.5 m in height at sites used by radio-collared deer in the two areas throughout the growing season with the help of 11 linear regression models. Vertical and lateral plant coverage over 2-m transects served as dependant variables in regression models to predict plant biomass by species (Rouleau et al. 2002b).

Data analysis – In a first step, we determined whether sex (for deer >1 year old) and age (fawns vs. >1 year old) influenced forage composition or quality as summer progressed using MANOVA. We restricted the analysis to the HD area because our samples from deer with known sex and age were too small in the LD area. Analyses were performed on sex and age with respect to months, including sex by month, and age by month interactions.

We used ANOVA for contrasting forage composition and quality between the two study areas. We pooled months two by two for this analysis to ensure adequate sample size for each period in both regions. ANOVA were followed by pairwise protected LSD tests (PROC GLM, PDIFF option, SAS Institute Inc. 1988). For all analyses, we ensured that residuals were normally distributed (Shapiro-Wilk test) and homogenous (visual inspection of the plot). For forage composition, we carried out ANOVA on ranks because we could not normalise residuals. We estimated means and their standard error with the LSMEANS statement (SAS Institute Inc. 1988).

Results

Rumen samples were collected from 93 deer (HD 68 / LD 25): 64 adults, 11 fawns, and 18 of unknown age. On a volumetric basis, 80% of the particles examined could be identified to 68 food items. Males and females showed no overall differences in the food items they selected in the HD area when considering forage categories ($F = 0.52$; df = 6, 38; $P = 0.79$) or diet quality ($F = 0.21$; df = 5, 22; $P = 0.95$), without sex × age interaction for composition ($F = 0.77$; df = 24, 134; $P = 0.76$) and quality ($F = 0.69$; df = 20, 74; $P = 0.83$). Neither did age influence forage composition ($F = 0.26$; df = 6, 49; $P = 0.95$) or quality ($F = 2.27$; df = 5, 28; $P = 0.08$), nor did it interact with month on a composition ($F = 2.31$; df = 6, 53; $P = 0.05$) or quality ($F = 1.43$; df = 5, 28; $P = 0.24$) basis. Given these results, we did not take into account age and sex in subsequent analyses.

Diet composition – Rumen contents differed between the two study areas (Figure 2). In spring, rumens contained no farm crops in LD but 13% in HD ($P = 0.03$). Grasses ($P = 0.08$) and flowers ($P = 0.07$) also tended to be more important food items in HD than in LD. Conversely, forbs ($P = 0.04$) and leaves of shrubs and trees ($P = 0.12$) accounted for a larger volume in LD samples. Diets during July-August were more comparable; the only significant difference was for forbs: 32% in LD vs. 7% in HD ($P = 0.01$). Rumens collected during September and October contained more mushrooms ($P < 0.01$) and leaves of shrubs and trees ($P = 0.08$) in LD, whereas those collected in HD included more fruits ($P < 0.01$) and grasses ($P = 0.08$).

Differences between the two study areas were more striking when considering taxa for the whole growing season (Table 1). For this comparison, we eliminated fruits, mostly apples, because they were almost restricted to HD and their more three-dimensional shape contrasting with that of most other two-dimensional plant tissues resulted in exceptionally large volume. Excluding fruits, 19 food items each accounted for more than 1% of the rumen volume in LD, summing up to 95 % of volume, compared with 20 food items making up 87 % of rumen content in HD. Forest forbs, such as Yellow Clintonia (*Clintonia borealis*) and Wild-Lily-of-the-Valley (*Maianthemum canadense*) were common food items in LD but rare in rumens collected in HD. They were replaced in HD by forbs typical of openings and by farm crops, such as clover (*Trifolium* sp.) and alfalfa. Mountain Maple (*Acer spicatum*) and Mountain Ash (*Sorbus americana*), the most common shrub leaves in rumens collected in LD, were replaced by Red Maple, Choke Cherry (*Prunus virginiana*), and Sugar Maple in HD; the latter species were also consumed by LD deer, but to a much lesser extent. Finally, apples, the most common item in HD rumens, were found in only one LD sample.

Diet quality – Nitrogen ($F = 0.91$; df = 1, 52; $P = 0.34$) and phenolic content ($F = 0.13$; df = 1, 52; $P = 0.71$)

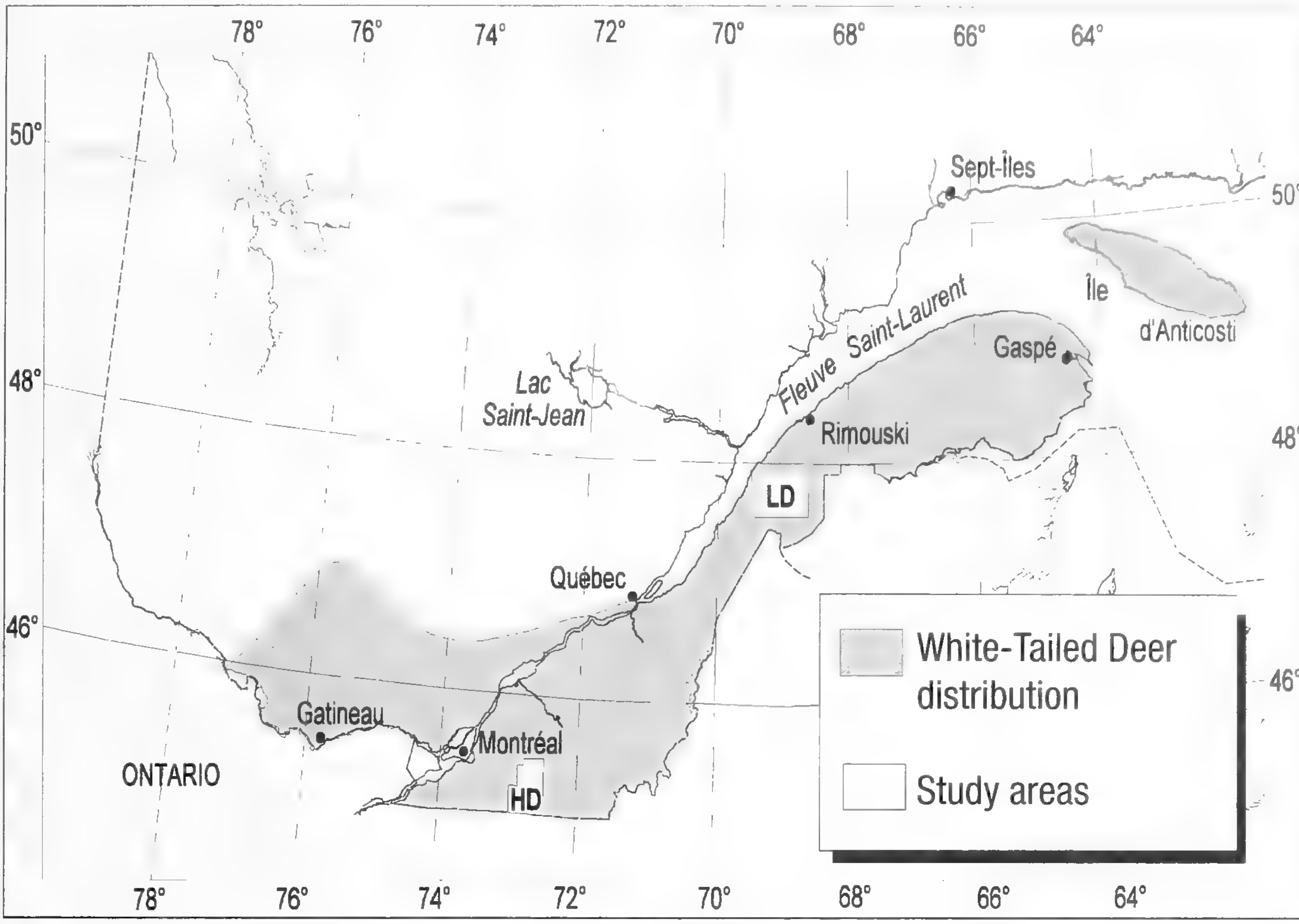

FIGURE 1. White-tailed Deer distribution in Québec and location of the two study areas, low density (LD) and high density (HD).

did not differ between the two areas, with nitrogen remaining stable as the growing season progressed, and phenolic content declining in September-October (Table 2). However, LD rumens contained more cell solubles ($F = 5.66$; df = 1, 69; $P = 0.02$) and lignin ($F = 4.68$; df = 1, 69; $P = 0.03$) than those from LD.

Discussion

Diet composition – Forage availability is reflected in diet composition. Although climate differed between LD and HD, the two regions shared most plant taxa and natural forage species had similar digestibility in both areas throughout the growing season (Lesage et al. 2000). However, biomass of preferred forage species found at sites used by deer was much larger in LD than HD (Rouleau et al. 2002a). Food items which dominated in LD diets remained almost absent from HD rumens. For instance Liliacae, such as Yellow Clintonia and Wild-Lily-of-the-Valley, which White-tailed Deer normally consume in the Northeast (Crawford 1982; Korschgen et al. 1980; McCaffery et al. 1974; Skinner and Telfer 1974; Waller and Alverson 1997) occupied a marginal volume in HD rumens. Liliacae are particularly vulnerable to deer browsing (Crête et al. 2001; Waller and Alverson 1997) and can be used as indicators to estimate the impact of White-tailed Deer on plant communities (Balgooyen and Waller 1995). Wild-Lily-of-the-Valley was common in HD in the early 1980s (Guérard and Legris 1984*). At the time of our study, its biomass was 20 times lower in HD than in LD (Rouleau et al. 2002a) and occurred as a marginal food item in the diet of HD deer (Table 1). Although not abundant on a volumetric basis, Wild-Lily-of-the-Valley occurred in 16% of the rumens collected in HD, showing that deer were still looking for this species even though its availability was largely reduced. Mountain Maple, which is known to be affected by deer (Balgooyen and Waller 1995), was a common species in HD in the past (Guérard and Legris 1984*), but seemed almost extirpated at the time of our study (Rouleau et al. 2002a). In LD, where natural forage is abundant (Rouleau et al. 2002a), Lesage et al. (2002) found that deer avoided cultivated fields. Our results support their findings and indicate that White-tailed Deer prefer to consume forest forages when they are readily available during the growing season. In HD, where most preferred food items had become scarce (Rouleau et al. 2002a; Boucher 2004), deer switched to other natural forage still persisting (e.g., Red Maple, Choke Cherry and Sugar Maple) and relied on farm

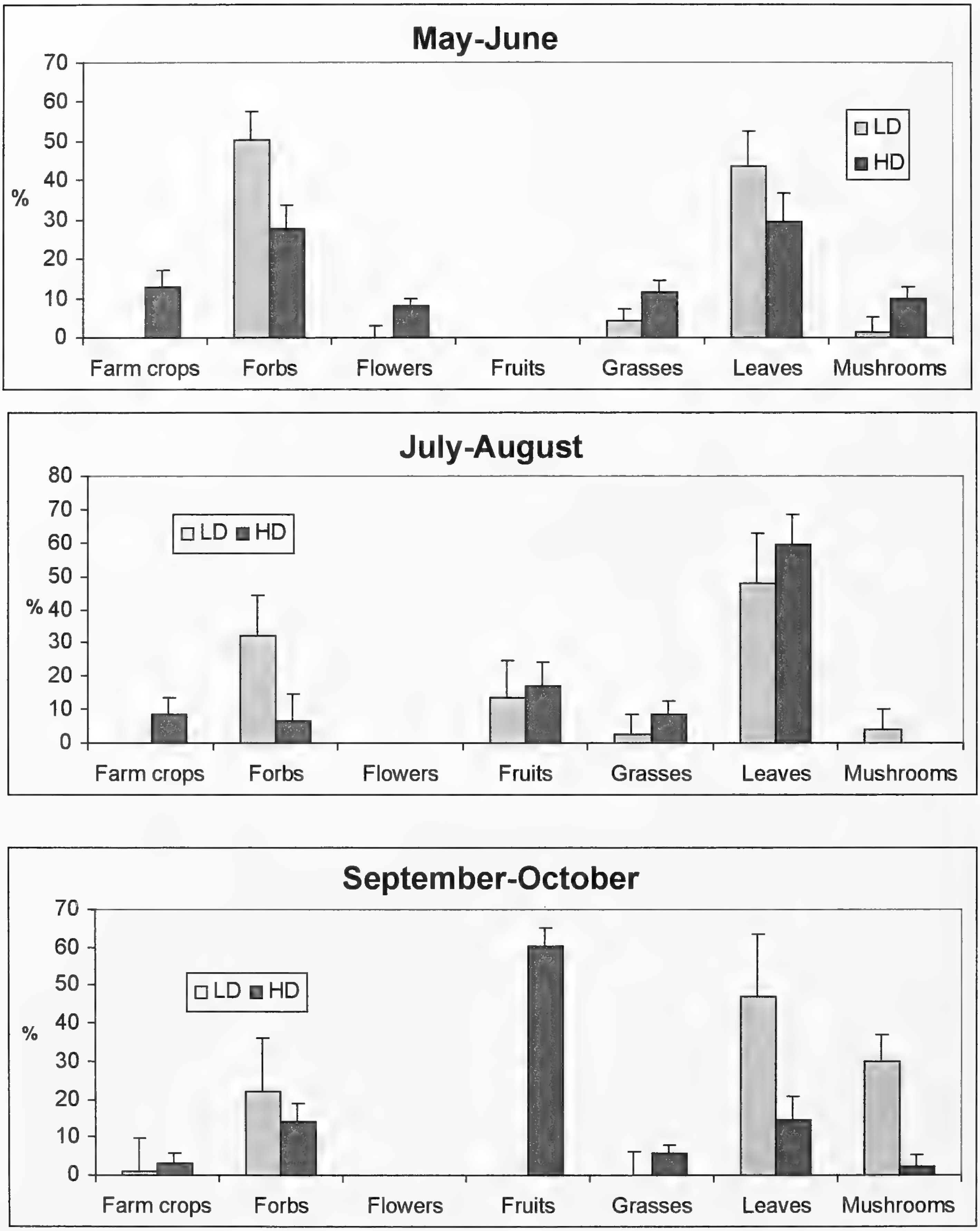

FIGURE 2. Composition (% volume ± SE) of rumen samples collected in a low-density LD (n = 25) and a high-density HD (n = 68) area of southern Québec during the growing seasons of 1997 and 1998.

crops for a large part of their summer diet. Comparison of forage availability and consumption (Table 1) suggests that Red Maple, Choke Cherry, and Sugar Maple suffered high browsing pressure in HD.

Fruits, mostly apples (90%), were a major component of the fall diet in HD. Our results support the idea that fruits are important food items where and when they are available (McCaffery et al. 1974; Short 1971;

TABLE 1. Most common food items (volume >1%) found in White-tailed Deer rumens from a low density LD (n=23) and a high density HD area (n=63) of southern Québec during the growing seasons of 1997 and 1998.

		% volume		% occurence		Availability (g/m^2)	
Food items	Category	LD	HD	LD	HD	LD	HD
Leaves, stems, and grain							
Acer spicatum	Leaf	26.9	0.6	30.4	4.8	19.0	<0.1
Fungi	Mushroom	14.7	16.4	26.1	20.6	<0.1	<0.1
Botrychium sp.	Forb	7.2	0	4.3	0		
Clintonia borealis	Forb	6.2	0.1	34.8	1.6	2.7	0.1
Maianthemum canadense	Forb	5.9	1.5	47.8	15.9	5.1	0.2
Sorbus americana	Leaf	4.4	0	26.1	0	<0.1	
Fraxinus nigra	Leaf	4.0	0	4.3	0		
Epilobium angustifolium	Forb	3.6	0	21.7	0	0.8	
Prunus virginiana	Leaf	3.6	8.9	21.7	28.6	<0.1	<0.1
Prunus pennsylvanica	Leaf	2.9	0.9	26.1	4.8	<0.1	
Trillium sp.	Forb	2.3	0.2	13.0	6.3	<0.1	<0.1
Aralia nudicaulis	Forb	2.3	2.1	8.7	6.3	2.3	<0.1
Acer rubrum	Leaf	1.9	10.3	21.7	41.3	2.6	0.1
Taraxacum officinale	Forb	1.9	2.2	13.0	12.7	0.9	0.2
Populus tremuloides	Leaf	1.7	1.7	13.0	9.5	4.3	0.1
Graminae	Grass	1.5	8.4	43.5	76.2	2.0	
Acer saccharum	Leaf	1.3	6.6	13.0	14.3	1.6	<0.1
Taxus canadensis	Leaf	1.3	<0.1	4.3	1.6		
Salix sp.	Leaf	1.1	0.5	8.7	4.8	<0.1	
Solidago sp.	Forb	0	1.2	0	4.8		
Fragaria sp.	Forb	0	1.5	0	19.0		0.1
Lotus corniculatus	Farm crop	0	1.6	0	1.6		
Prunus serotina	Leaf	0	1.9	0	11.1		0.3
Sonchus sp.	Forb	0.2	1.9	4.3	3.2		<0.1
Rubus sp.	Leaf	0.7	2.3	8.7	27.0		
Potemogeton sp.	Forb	0	3.0	0	3.2		
Malus pumila	Leaf	0	3.2	0	6.3		
Zea mays	Farm crop	0	3.6	0	7.9		
Medicago sativa	Farm crop	0	3.8	0	7.9		
Trifolium sp.	Farm crop	0.1	4.8	4.3	20.6		
Fruits							
Malus pumila	Fruit	100	90.1	4.3	36.5	<0.1	<0.1
Quercus sp.	Fruit	0	3.6	0	1.6		
Fragaria sp.	Farm crop	0	3.1	0	1.6		
Crataegus sp.	Fruit	0	2.2	0	6.3		

Skinner and Telfer 1974). Apple trees and oak are absent from forests in LD. We assumed that apples found in one LD sample came from baits set by hunters. Baiting was also common in HD, but we think that apples ingested by deer in this region primarily originated from uncultivated apple trees growing in young forests based on the fact that most specimens found in rumens were smaller than commercial apples.

Mushrooms were a common food item in both study areas. Like apples, but to a lesser extent, their shape and size may have exaggerated their relative importance on a volumetric basis. Their frequent occurrence in rumens indicates that they represented a common food item for White-tailed Deer. Mushrooms were consumed mostly in spring in HD and in fall in LD, which may be explained by different seasonal availability or by the possibility that White-tailed Deer feed on them when preferred foods are rare at both ends of the growing season. Many studies reported large amounts of mushrooms in White-tailed Deer diet (Crawford 1982; Johnson et al. 1995; Korschgen et al. 1980; McCaffery et al. 1974), but nobody has yet considered the potential impact of deer herbivory on mushrooms.

Diet quality – LD deer had access to a greater biomass of preferred forage (Rouleau et al. 2002a) and consumed more forbs and leaves of shrubs and trees than HD deer, which compensated by ingesting farm crops, grasses and fruits. Different forage intake resulted in a diet containing more cell solubles and lignin in LD than in HD deer. Rumen contents did not differ with respect to phenolics, which may have reflected the complex nature of the chemical group (Robbins 1993: 253). Protein content followed a similar trend as that for cell solubles, although the difference between LD and HD was small and non-significant. Between May and September, cell solubles were 8% greater in LD than HD rumens. Cell solubles, which are composed of sugars, protein, non-protein nitrogen, lipid, organic

TABLE 2. Mean (SE; n) content (%) of cell solubles, lignin, phenolics, and nitrogen in White-tailed Deer rumen samples collected in a high-density (HD) and a low-density (LD) study area of southern Québec during the growing seasons of 1997 and 1998.

	May-June		July-August		September-October	
	HD	LD	HD	LD	HD	LD
Cell solubles	32.4	40.7	34.1	42.7	40.7	39.9
	(1.4; 21)	(2.0; 14)	(1.8; 11)	(2.1; 4)	(1.5; 23)	(2.5; 2)
Lignin	22.2	23.3	21.9	23.4	17.8	24.0
	(1.0; 21)	(1.2; 14)	(1.4; 11)	(2.3; 4)	(1.0; 23)	(3.3; 2)
Phenolics	3.5	3.6	3.4	3.5	2.4	2.7
	(0.1; 16)	(0.2; 13)	(0.2; 7)	(0.3; 4)	(0.1; 16)	(0.4; 2)
Nitrogen	7.2	7.0	6.8	6.5	6.9	7.0
	(0.3; 16)	(0.3; 13)	(0.4; 7)	(0.6; 4)	(0.3; 16)	(0.8; 2)

acid and soluble minerals (Iason and Van Wieren 1999), are highly and rapidly digestible, whereas cell walls (1-cell solubles) are only partly digestible and necessitate some retention in the rumen for microbes to degrade them (Iason and Van Wieren 1999). LD does benefited therefore from a richer diet than HD counterparts during the end of gestation and peak lactation, a period with elevated energy demand in cervids (Mauget et al. 1997). In late summer, the high consumption of apples, which contain little fiber (Robbins 1993), can explain the improved quality of rumen contents in HD. The higher concentration of lignin in LD than in HD rumens likely came from the greater consumption of farm crops and grasses in the latter area, which have a lower level of lignin than natural forages do (Robbins et al. 1987).

The difference in forage quality likely reduced the growth and condition of White-tailed Deer in HD, where strong competition for forage has prevailed. Deer density in HD increased by 10 fold since the late 1970s, whereas it remained relatively low and stable in LD (Lesage et al. 2001). Deer had the same size in both study areas before 1987 (Potvin 1989), but their body mass progressively decreased in HD (Lesage et al. 2001; Potvin 1994*). At the time of our study, the eviscerated carcass mass of fully grown male deer averaged 80 vs. 116 kg in HD and LD, respectively (Lesage et al. 2001). Additional measurements throughout the deer range in Québec revealed that deer size began to decline when forage competition intensified in summer; i.e., forage availability <10 000 kg/deer (Boucher 2004). Our results concur with the hypothesis that rural deer living at high density cannot fully compensate for the rarity of natural forage in woodlots during summer by consuming cultivated plants (Rouleau et al 2002a). All of these studies suggest that deer populations have reached excessive densities in HD.

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Winter Habitat Use by Wolves, *Canis lupus*, in Relation to Forest Harvesting in West-central Alberta

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Forested landscapes in west-central Alberta are facing increased pressures from forest harvesting and other land-use activities, which may alter the movements and distribution of Wolves and ungulates. Information on habitat use by Wolves in logged forests is scarce, potentially limiting effective land-use planning in the boreal forest. Nine Wolves, from four Wolf packs, were fitted with GPS radiocollars in the Rocky Mountain foothills, near Grande Cache, Alberta (2000-2001). We found Wolves did not use the landscape randomly, but rather exhibited a significant preference for non-forested natural habitats (shrubs, water), relative to their availability. Within forest habitats, Wolves used cutblocks proportionately more than unharvested forest and non-forested anthropogenic habitats (pipelines, clearings); however, selection of forest cutblocks was not statistically significant. We found no evidence that Wolves preferred or avoided forest cutblock edges. Wolf pack territories contained various levels of timber harvesting, but most areas were still in the early stages of harvest. Nevertheless, these areas have been allocated for large-scale harvesting. Understanding the potential responses of Wolves to rapidly changing landscape mosaics poses a significant challenge to researchers and managers, but such information is important to informing future land-management and conservation strategies for boreal forest Wolf-prey systems.

Key Words: Wolf, *Canis lupus*, Caribou, *Rangifer tarandus*, forestry, habitat, Moose, *Alces alces*, predation, Alberta.

Much of the world's boreal forest is undergoing increased demands from resource extraction industries, where related activities such as forest harvesting may alter habitat use by large carnivores (McLellan and Hovey 2001; White et al. 2001). Wolves (*Canis lupus*) are a common predator of ungulates in Canada's forests, yet there are few data on how their use of habitat might be affected by forest harvesting (Jedrzejewska et al. 1994; Kohira and Rexstad 1997; Kunkel and Pletscher 2000). Logging of forests can change the spatial dynamics of Wolves and their prey, resulting in conflict between resource development and wildlife management (Hervieux et al. 1996). For example, in Alberta, Woodland Caribou (*Rangifer tarandus caribou*) are classed as a threatened species (Edmonds 1998), and Wolf predation is considered a primary reason for their decline (Edmonds 1988; McLoughlin et al. 2003). It is therefore important to understand how Wolves respond to forest harvesting, as habitat use by Wolves may change in response to logging activities, and could affect predation risk to Caribou and other ungulates.

Forest harvesting can cause habitat fragmentation and alter predator-prey systems. Predators may follow habitat edges due to ease of travel (Bider 1968). As well, when patch size decreases, predator numbers may increase due to increased prey density and diversity (Gates and Gysel 1978; Yahner 1988). For example, Red Fox (*Vulpes vulpes*) and Coyote (*Canis latrans*) densities can increase with more landscape fragmentation, and habitat edges are favored for hunting (Oehler and Litvaitis 1996).

In a Wolf-prey system in Canada's boreal forest, forestry activities have the potential to alter the predation risk to ungulates from Wolves in three ways. First, differential spatial and temporal habitat selection separates Woodland Caribou and Moose (*Alces alces*) distribution, reducing the risk of predation to Caribou from Wolves (Bergerud and Elliot 1986). Caribou selection for higher elevations reduces the chance of encounter by Wolves hunting Moose, a primary prey species, in lower elevations riparian areas (Seip 1992). If the spatial separation of Caribou and Moose is altered by logging roads and forest cutblocks, it has been argued that Wolves will have increased access to, and greater encounter rates with Caribou, resulting in a Caribou decline (Bergerud 1988; Seip 1992). In northeast Alberta, linear developments (roads, seismic lines, trails) were found to affect the spatial separation between Caribou and Moose, where linear corridors enhanced Wolf travel efficiency (James 1999) and Caribou mortalities caused by Wolves were found closer to linear corridors than expected by chance (James and Stuart-Smith 2000).

Second, Caribou select for older forests (Szkorupa 2002) and distribute at low densities (Bergerud 1988). Caribou spatial overlap with Wolves is reduced and, correspondingly, so too is the risk of detection and predation. Reducing the amount and patch size of older forest by timber harvest may temporarily increase Caribou densities (Bergerud 1988), and Moose, deer (*Odocoileus* spp.) and Elk (*Cervus elaphus*) may use these remaining patches for cover. Higher densities of

Caribou in more constricted areas, and wider distribution of Wolves in response to primary prey distribution, may increase the chances of Caribou being detected by Wolves.

Third, Moose, Elk and deer are attracted to recently logged areas that support high quality regenerating forage (Peek et al. 1976; Tomm et al. 1981; Stelfox et al. 2001). This represents a concentrated prey base for Wolves, which may influence how Wolves use landscapes. If Wolves frequent forest cutblocks searching for Moose, Elk and deer, and if cutblocks occur near preferred Caribou habitats, this may increase predation risk to Caribou. All three outcomes potentially affecting Caribou depend on information about Wolf behavior and use of changing landscapes.

Forest harvesting in west-central Alberta was largely initiated in the late 1960s and has accelerated in recent years. Energy sector activities (oil and gas exploration and development) are also altering these landscapes, resulting in cumulative land use impacts (Hervieux et al. 1996). For decisions concerning long term wildlife conservation, resource managers and land-use planners require new information about how Wolves use habitat in logged forests and under changing landscape conditions.

We used Global Positioning Systems (GPS) radio-collar technology to examine winter habitat use of Wolves in west-central Alberta. We chose to examine fine-scale Wolf movements that correspond with Johnson's (1980) third order habitat selection: movements of animals within their home range. We examined two questions. First, do Wolves use forest cutblocks preferentially over other habitat types? Second, do Wolves prefer cutblock edges? We predicted that Wolves would prefer forest cutblocks over other habitats, due to the expected increase in ungulate densities in regenerating forests. We also predicted Wolves would prefer forest cutblock edges relative to areas farther away from them, due to ungulate use of cutblock edges for feeding and proximity to cover (Stelfox et al. 2001*).

Study Area

The study area is approximately 5000 square kilometers, located in the foothills of west-central Alberta, near the town of Grande Cache (54°N 119'W) (Figure 1). The area is classed into subalpine and boreal natural subregions (Beckingham and Archibald 1996), and contains several main rivers and a dendritic pattern of creeks; lakes are scarce. Elevations range from 1300-1800 meters, and the climate is subarctic, with

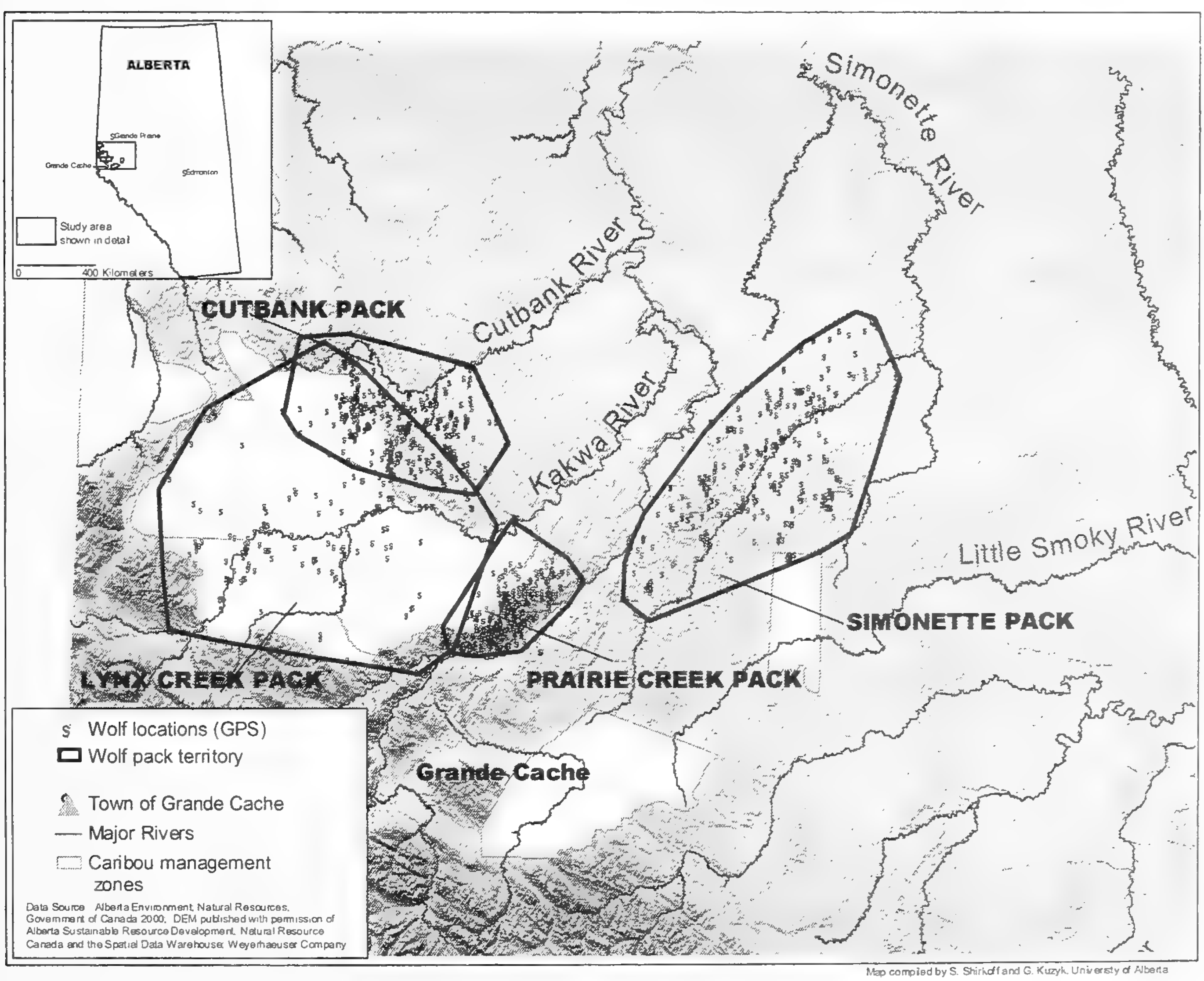

FIGURE 1. Distribution of four Wolf packs monitored in winters of 2000 and 2001 in west-central Alberta.

short wet summers and long cold winters. Temperatures average 16°C in July and -13.5°C in December (Beckingham and Archibald 1996). The forests are primarily Lodgepole Pine (*Pinus contorta*) and some White Spruce (*Picea glauca*). The wetland complexes support mostly Black Spruce (*Picea mariana*) and some Tamarack (*Larix laricina*). Some south facing slopes support Trembling Aspen (*Populus tremuloides*) and willow (*Salix* spp.).

This area supports a high diversity of large mammals: Woodland Caribou, Moose, Elk, Mule Deer (*Odocoileus hemionus*), White-tailed Deer (*Odocoileus virginianus*), Bighorn Sheep (*Ovis canadensis*), Mountain Goats (*Oreamnos americanus*) and Wild Horses (*Equus cabalus*). Wolves, Coyotes (*Canis latrans*), Grizzly Bears (*Ursus arctos*), Black Bears (*Ursus americanus*) and Cougars (*Felis concolor*) also exist throughout the study area.

Major land use activities include forest harvesting, oil and gas exploration and development, coal mining, commercial trapping, and public uses such as hunting, fishing, hiking, horse packing and camping. Access is primarily on roads created for resource extraction, pipelines and seismic lines. Further descriptions of the study area can be found in Edmonds (1988) and Smith et al. (2000).

Wolf Location Data

Nine Wolves in four packs were captured and fitted with GPS radiocollars in winters of 2000 and 2001 (Table 1). Three packs were located in areas with a migratory mountain Caribou population and one pack with a sedentary boreal Caribou population. All Wolf handling was approved by the Faculty of Agriculture, Forestry and Home Economics Animal Care Policy (Number 96-99D), subject to the protocols of the Canadian Council of Animal Welfare. Wolf captures were accomplished by helicopter darting (Ballard et al. 1991) or netgunning, then physically restraining the Wolf with restraining forks, and hand-injecting 1-2 mls of telazol at 200 mg/ml (Kuzyk 2002a). Wolves were fitted with store aboard GPS radiocollars (Lotek Engineering Sytems, Newmarket, Ontario). In the winter of 2001, the Prairie Creek and Cutbank packs each had two members with GPS radiocollars. To avoid pseudoreplication (Hurlburt 1984), location data and associated patterns of habitat use from these individuals were averaged for their respective packs (Table 1).

As this study was designed to understand Wolf habitat use in winter, the following criteria were used to select Wolf location data:

(1) Location data from 31 January to 25 April 25 in 2000 and 2001 were used for analyses. These dates were used for two reasons: first, most Caribou in the study area (the migratory mountain ecotype) leave the forested foothills in late winter and spring to calve in the nearby mountains (Edmonds 1988); second, a spring cutoff time also has ecological relevance to Wolves. In spring near whelping time, Wolves are thought to change their hunting patterns by switching from hunting as a pack and preying on ungulates, to hunting alone or in small units in search of smaller prey, with their activities centering on the den and pups (Mech 1970). Therefore a single GPS collared Wolf would no longer represent the behavior of their pack, and would not meet our design criteria.

(2) To provide consistency in GPS collar programming, six-hour locations were chosen (4 per day) as the minimum common sampling unit for analysis. Wolves are sporadic in their movements, and may travel at rates of about 8 km/hr while hunting (Mech 1966), or relatively short distances when near a killsite (Kuzyk 2002a). When near a killsite, they seldom rest in one location for periods longer than six hours (Mech 1970).

(3) Wolf locations outside calculated pack territories were not used. These Wolves were assumed to be dispersing from their natal territory and thus behaving differently from their pack (Gese and Mech 1991).

Data were differentially corrected using N4Win Version 2.40 program (Lotek Engineering Inc. 2000) and were assumed accurate within 14 meters, 95% of the time (Lotek Engineering Inc. 2000). Wolf locations with Dilution of Precision (DOP) values greater than 15 were removed from the analysis (<2 % of total locations). High DOP values and radiocollar malfunctions made for unequal locations per Wolf pack (range 152 to 279) over the duration of this study (Table 1).

Habitat Classification and GIS Methods

Wolf location data were imported into ArcView Version 3.1 (Environmental Systems Research Institute Inc., Redlands, California). Current, digital forest inventory coverages were obtained from Weyerhauser Canada Limited, Canadian Forest Products and Al-

TABLE 1. Wolf packs with associated number of GPS locations and area of habitat use (territory size) in west-central Alberta in winters of 2000 and 2001.

Wolf Pack	Wolf	Year	Dates	Number of Locations	Area (km^2)
Cutbank	W5	2000	24 January – 16 March	185	714
Prairie Creek	W9	2000	28 January – 25 April	252	286
Simonette	W13	2000	31 January – 25 April	279	786
*Prairie Creek	W5 and W9	2001	18 February – 25 April	231	182
*Cutbank	W19 and W21	2001	15 February – 25 April	258	448
Lynx Creek	W22	2001	15 February – 25 April	247	1848
Simonette	W30	2001	17 February – 4 April	152	398

* Locations were averaged for two collared Wolves which belonged to the same pack.

TABLE 2. Description of habitat categories used in compositional analysis for Wolf packs in west-central Alberta during late winters of 2000 and 2001.

Habitat 1	Habitat 2	Habitat 3	Habitat 4
Forest cutblocks all harvested forest	Unharvested forest all harvestable forest burn	Non-forest (natural) herbaceous grassland sand, flooded land closed and open shrub coniferous scrub deciduous scrub brush, windfall open and treed muskeg water	Non-forest (anthropogenic) clearing right-of-way industrial infrastructure pipelines geophysical perennial forest crops*

*Perennial forest crops are denoted as anthropogenic by the forest companies and account for < 0.6km^2 of one Wolf pack's territory. (Simonette pack – total territory size is 786 km^2).

TABLE 3. The percentage of use (GPS locations) and availability (area in km^2) of five habitat categories for Wolf pack territories in west-central Alberta during late winters of 2000 and 2001.

		Cutblock		Forest		Non-forest* Shrubs		Non-forest* Water		Non-forest Anthropogenic	
Wolf Pack	Year	Used_1	Avail_1	Used_2	Avail_2	Used_3	Avail_3	Used_4	Avail_4	Used_5	Avail_5
Cutbank	2000	34.1	28.9	57.8	64.6	7.0	5.4	1.1	0.3	0.0	0.8
Prairie Creek	2000	11.9	12.5	77.8	80.2	6.7	4.8	1.2	1.0	2.4	1.5
Simonette	2000	21.1	15.9	61.6	78.8	7.5	3.0	2.5	0.6	7.2	1.8
Prairie Creek	2001	6.3	5.9	81.2	87.1	9.1	4.1	1.7	1.1	1.7	1.8
Cutbank	2001	43.3	35.5	35.7	60.0	20.2	3.4	0.4	0.3	0.4	0.8
Lynx Creek	2001	0.8	5.4	77.3	85.9	20.2	8.5	0.8	0.1	0.8	0.2
Simonette	2001	16.4	14.0	68.4	78.3	13.2	5.5	0.7	0.5	1.3	1.7
Total	Mean	19.1	16.9	65.7	76.4	12.0	5.0	1.2	0.6	2.0	1.2
	SE	5.7	4.3	6.0	3.9	2.3	0.7	0.3	0.1	0.9	0.2

*Non-forest natural is subdivided into shrub and water categories for descriptive purposes only.

berta Government Phase 3. The minimum mapping unit for these coverages was 1 ha for forest polygons. However, the resolution of line features, such as roads, was much greater, as these were spatially referenced from high-resolution remotely sensed data (~5 m resolution), or from GPS readings taken in the field. Thus, the resolution of our animal location data was commensurate with the resolution of the landscape coverages used, for purposes of evaluating coarse-scale habitat use. Minimum convex polygons (MCPs) of Wolf territories were initially calculated with an animal movement extension in ArcView (Hooge and Eichenlaub 1997). MCPs were considered an appropriate method for delineating general territory boundaries in order to evaluate coarse-scale habitat use. Due to a small portion of the GIS coverages missing within each Wolf pack territory, territory sizes for subsequent analyses were adjusted by summing all the areas within the MCPs for which we had GIS coverages (Table 1).

As Wolves live in a defined territory (Mech 1970), each territory was classified into four habitat categories to reflect coarse scale patterns of use. These categories were: (1) forest cutblocks, (2) unharvested forest, (3) non-forest natural (shrubs and water) and (4) non-forest anthropogenic (pipelines, wellsites) (Table 2). The area of non-forest natural was divided into "shrub" and "water" classes for descriptive purposes (Table 3), but the data were pooled for analysis. As the focus of this study was to determine habitat use of Wolves in managed landscapes, a further analysis was conducted to determine Wolf use of forest cutblock edges. Forest cutblocks were buffered using specified distances starting from the edge of the forest-cutblock and proceeding into the forest. We did not use locations inside cutblocks in this analysis. Buffer distances were consistent with those studying Caribou avoidance of linear features (Dyer et al. 2001; Oberg 2001), starting from the edge of the cutblock to 100 m, 101-250 m, 251-500 m, 501-1000 m and >1000 m. The category of >1000 m was also chosen as the farthest distance for comparison to Smith et al. (2000), who found that Caribou in west-central Alberta may avoid cutblocks by about 1200 m.

Statistical Analysis

Compositional analysis (Aebischer et al. 1993) was conducted by integrating Wolf GPS location data and forest inventory data within a GIS (ArcView 3.1) to

determine if there was a preference in Wolf use of habitat or buffer categories. Aebischer et al. (1993) suggest a minimum of six radiotagged animals are required to perform compositional analysis, and replication across years is acceptable. Therefore, our sample of seven Wolves over two winters was adequate for this test. Compositional analysis compares the amount of "used habitat" to the amount of "available habitat" and tests whether habitats are preferred or avoided more than expected by random (Johnson 1980). The number of Wolf locations in each habitat or buffer category represented used habitat. The available habitat was the total area of each habitat or buffer category (Table 3). If there was no use of a habitat category, 0% use was replaced with 0.001%, as this represented a value lower than the smallest recorded nonzero percentage (Aebischer et al. 1993).

A chi-square test was used to determine if Wolf use of habitat or buffer categories was significantly non-random, then each habitat category was ranked in terms of its use. To determine if any habitats were selected over others, a difference for each pair-wise comparison was calculated using log ratios. This compared each habitat category within each Wolf pack territory. The means and standard errors for each comparison were calculated across all Wolf packs, and the pair-wise differences were tested for significance using a t-test (Aebischer et al. 1993). Alpha level for all tests was set at 0.05.

Results

Wolf Habitat Use

Territory size for the four Wolf packs ranged from 182 – 1848 km^2 (Table 1). The availability of each of the four habitat categories varied markedly: the percentage of forest averaged 76.40% (SE 3.90) for all packs, and thus was the most dominant habitat, whereas non-forest anthropogenic cover averaged only 1.23% (SE 0.25) of available habitat across Wolf territories (Table 3). Wolves showed a significant deviation from random use of the four habitat types ($\chi^2 = 7.815$, df = 3, p = 0.036) selecting non-forest natural (shrubs-water) habitats over both forest (t = -4.281, df = 6, p = 0.005) and cutblocks (t = -2.92, df = 6, p = 0.027), in relation to their availability (Table 4). No other pair-wise comparisons were significant. However, when ranked in preference by habitat type, forest cutblocks were preferred more than both forest and non-forest anthropogenic areas.

Wolf Response to Forest Cutblock Edges

The available areas for all distance buffers less than 1000 m were similar, with variation due mostly to dissolving buffers for adjacent cutblocks. Wolf use of distance buffers did not deviate significantly from random ($\chi^2 = 2.349$, df = 3, p = 0.503). When buffer distances were compared using compositional analysis, no significant difference was found between distance categories related to forest cutblock edges. When ranked, the 501-1000 m buffer distance was the most preferred, followed by the 0-100m buffer, with the least preferred being the buffer >1000 m.

Discussion

Wolves have been described as habitat generalists (Mech 1970; Mladenoff et al. 1995). On a coarse spatial scale, Wolves inhabit large tracts of forest (Mech 1995) and may prefer mixed wood forests over either homogenous coniferous or deciduous forests (Mladenoff et al. 1995; Krizan 1997). Wolves may use forests altered by logging, as these areas provide good deer habitat, and thus support an important prey base for Wolves (Mladenoff and Sickley 1998). In this study, GPS radiocollar technology allowed for a more refined examination of Wolf habitat preferences, showing Wolves in our study area do not use the landscape randomly. In general, Wolves preferred habitats with young vegetation, in both non-forest natural habitats and forest cutblocks. This is consistent with increased ungulate abundance in areas of young vegetation (Peek et al. 1976; Stelfox et al. 2001*), which attract Wolves (Bergerud 1988). However, increased road access into these areas may also allow humans to alter activity patterns of Wolves (Theuerkauf et al. 2003), or affect Wolf numbers by direct or indirect killing (Mech 1995, Mladenoff and Sickley 1998). In this study, the least used habitat by Wolves was non-forest anthropogenic (pipelines, right-of-ways), possibly to avoid human contact. Two radio-collared Wolves were known to have been shot during this study, and several other collars were lost to unknown factors (Kuzyk 2002a).

We found little support for our first prediction that Wolves select forest cutblocks. Wolves did use cutblocks proportionately more than their availability and were ranked above forest or anthropogenic features,

TABLE 4. Results from compositional analysis (p values in parenthesis; + denotes row > column and – column > row) for comparing four habitat categories for four Wolf packs in west-central Alberta during late winters of 2000 and 2001.

	1 Cutblock	2 Forest	3 Non-for_natural	4 Non-for_anthropogenic
1 Cutblock		+(0.947)	-(0.027) *	+(0.902)
2 Forest	-		-(0.005) *	+(0.903)
3 Non-for_natural	+	+		+(0.177)
4 Non-for_anthro.	-	-	-	

* denotes significance at (p<0.05).

but differences were not significant. Similarly, Wolves in Ontario were found to use cutblocks in proportion to their occurrence (Krizan 1997). We had the advantage of GPS radiocollars which allowed for a large collection of location data, compared with the traditional VHF collars used by Krizan (1997). However, we acknowledge that our analyses still lacked statistical power, due to the relatively small sample of Wolves radiocollared.

The amount of harvested forest differed substantially between Wolf packs and may have accounted for variation in Wolf use of forest cutblocks. The Lynx Creek pack had only 5% of its territory as forest cutblocks, whereas 36% of the Cutbank pack's territory consisted of recent cutblocks. This seven-fold difference in the amount of harvested forest between packs may have influenced habitat preferences. Kohira and Rexstad (1997) found no evidence that Wolf diets differed between logged and unlogged areas in the coastal rainforests of Alaska. About 6% of that total study area was logged, with the amount of area logged ranging from 1-26% between Wolf pack territories. This differs from our study area, where about 17%, or approximately three times as much area has been logged. In southeast British Columbia, researchers also did not find evidence that forest harvesting increased the vulnerability of Moose to predation by Wolves, where about 13% of the area was logged (Kunkel and Pletscher 2000).

Wolves in our study did show a significant preference for non-forested natural habitats (shrubs/water) over cutblocks and forest, which might be explained by a number of selection criteria. Wolves prefer to rest in open areas, and may travel several kilometers to reach such preferred sites (Mech 1970). Wolves in this study area were observed on numerous occasions resting in open meadows, muskegs, hillsides and beaver ponds, often when they were near killsites (Kuzyk 2002a). The shrubs in these habitats have open crowns, which allows both penetration of sunlight and structure for protection from the wind, thus providing Wolves cover while resting.

The shrubs in this non-forest habitat type also provide forage and cover for ungulates. During this study, Wolves made deer kills in shrubby willow areas, and Moose, deer and Elk kills in or near riparian areas (Kuzyk 2002a). Elk are primarily grazers, and may be attracted to these shrub patches due to the increased availability of grasses. Bjorge and Gunson (1989), in a nearby Wolf study, noted that Elk, especially Elk calves, were a preferred prey for Wolves in winter. During the limited kill rate work associated with this study (Kuzyk 2002a), only one cow Elk kill was documented. In Jasper National Park, Wolves hunt deer while moving to pockets of Elk (Carbyn 1974; Weaver 1994). It is possible that shrubby areas do represent reliable patches of prey, and the Wolves investigate them for prey regularly.

Water was also included in this preferred habitat class. It is common for Wolves to use frozen waterways as travel routes where snow is most compacted and ice makes travel easy. In winter Wolves probably use creeks and rivers to travel among ungulate winter ranges. Also there is an increased chance of encountering Moose that use riparian areas in winter (Hayes et al. 2000) and Wolves are known to frequently kill ungulates on iced surfaces (Mech 1991).

Our second prediction of Wolf preference for forest cutblock edges was also not supported. There was no significant difference in Wolf preference for any buffer distance categories, nor was the 0-100 m buffer class ranked highest. Habitat was not controlled for in the buffer categories, which may have confounded the analysis. The behaviors of Wolves, such as feeding at killsites, resting and hunting may also be diluting the effect of any preference or avoidance of cutblock edges. Wolves hunt a diversity of prey, and chase distance varies with each prey type (Paquet 1989). For example, the average chase distance for a Moose is 883 m (Paquet 1989). Depending on where Wolves locate them, Moose could choose to run to the nearest forest to avoid attacking Wolves (Stephens and Peterson 1984), or remain stationary and aggressive (Mech 1966), or stationary and non-aggressive (Kuzyk 2002b), and still avoid attack by Wolves. These results, and those related to broader habitat selection questions, suggest that consideration of behaviors associated with different habitat types is an important component of interpretation in Wolf habitat use studies.

Forest harvesting alters both the amount and spatial distribution of habitat types. We measured habitat use by Wolves directly, and found that Wolf use of landscapes was not random. We suggest that patterns of habitat use may be influenced by the relative availability of different habitat types, specifically natural shrubs and waterways, and to a lesser degree, by recent forest cutblocks. Nevertheless, our results clearly show that consideration of shrub/waterway habitats is an important criterion for land-use decisions regarding Wolves. In our study area, Caribou prefer forests greater than 80 years old, especially those stands aged 120-160 years (Szkorupa 2002), and have been found to avoid forest cutblocks by 1200 m (Smith et al. 2000). As most of the winter range of these Caribou has been allocated for timber extraction, areas of older forest will become increasingly small and isolated. If the forest continues to be harvested at present rates, all Wolf packs we studied will have a substantial amount of logged area within their territories within a relatively short time. As Moose, deer and Elk are the primary prey of Wolves in this study area, information is required on how these ungulates are responding to the changing landscape mosaic, as this may ultimately determine how Wolves use the landscape. Understanding the dynamic relationship between predator and prey in a system undergoing rapid change

poses an enormous challenge. Future research on Wolf habitat use should concentrate on increasing sample sizes, refining habitat classifications, and linking behavior with patterns of habitat use.

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Bird Communities of the Garry Oak Habitat in Southwestern British Columbia

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Identifying the bird communities of a habitat could contribute to conservation efforts and provide benchmarks for ecosystem studies. Garry Oak (*Quercus garryana)* ecosystems in British Columbia are among the most endangered in Canada and warrant conservation. Four bird communities were determined by analyzing an extensive sample of Garry Oak habitat bird data. These communities were defined objectively by aggregations of the bird species themselves from across the various sites and areas. Characteristic species of these communities include American Goldfinch (*Carduelis tristis*), Spotted Towhee (*Pipilo maculatus*), Bewick's Wren (*Thryomanes bewickii*), Rufous Hummingbird (*Selasphorus rufus*) and Chestnut-backed Chickadee (*Poecile rufescens*) in community 1; House Wren (*Troglodytes aedon*), Olive-sided Flycatcher (*Contopus cooperi*), Purple Finch (*Carpodacus purpureus*), White-crowned Sparrow (*Zonotrichia leucophrys*), and Pine Siskin (*Carduelis pinus*) in community 2; Western Tanager (*Piranga ludoviciana*), Yellow-rumped Warbler (*Dendroica coronata*), American Goldfinch, Pine Siskin, Pacific-slope Flycatcher (*Empidonax difficilis*), Cassin's Vireo (*Vireo cassinii*) and Chipping Sparrow (*Spizella passerina*) in community 3; and Northwestern Crow (*Corvus caurinus*) and European Starling (*Sturnus vulgaris*) in community 4. Differences between the communities are suggested from the life history traits of the species, including a community consisting mostly of insectivores when on breeding territory (number 1), one with species foraging primarily in shrubs and trees (community 3), and another with tree-nesting ground gleaners (number 4). One community (number 3) had analogues in two widely disparate areas: oak-associated in north-central New Mexico, and aspen (*Populus tremuloides*)-related in northcentral British Columbia; otherwise communities reported in the literature were generally not directly comparable.

Key Words: bird communities, Garry Oak, *Quercus garryana*, multivariate classification, British Columbia.

Garry Oak, *Quercus garryana* habitat is unique within Canada, and related biogeographically to California (Erickson 1996). Garry Oak ecosystems are at their northern margin in British Columbia, and are among the most endangered ecosystems in Canada (Erickson 1993*, 2000a). Native stands have been reduced by urban development and are threatened with invasion by alien species. Bird communities of Garry Oak habitat in the Pacific Northwest have not yet been fully investigated. Defining these communities is a basic step toward conservation, and a requisite to identifying critical habitat requirements. Predictive abilities and assessments for preservation and management of the Garry Oak habitat could be strengthened by further understanding these communities.

Garry Oak occurs in an area of southwestern British Columbia with a distinctive modified mediterranean climate in the strong rain-shadow of the Olympic and Vancouver Island mountains. Mild, wet winters, variable precipitation and regular summer drought are typical. The result on the landscape is a mosaic of parklands with spring forb meadows and oak clumps; mossy bluffs often with shrub oaks; open grassy savannahs; and woodlands sometimes mixed with Douglas-fir (*Pseudotsuga menziesii*). As well as being diverse and productive for plant growth, this landscape is attractive for human habitation and agricultural development. The consequence has been habitat loss and endangerment for Garry Oak ecosystems. There is a scientific and conservation interest in knowing more about the elements of these ecosystems, including their bird communities. Garry Oak habitat has been selected as a focus of Partners in Flight for its importance to migrating and wintering birds in the Pacific Northwest (de Groot et al. 2000). Their work includes restoration of habitat within the British Columbia range of Garry Oak (Figure1).

The purpose of this paper is to identify the bird communities of Garry Oak habitat, make comparisons of the life history traits of constituent species, and compare these communities with the literature on other habitats.

Methods

I used Detrended Correspondance Analysis (DCA, PCORD 3.0, McCune and Mefford 1997*) (Hill and Gauch 1980; Peet et al. 1988); interpretive graphing; and a quantitative similarity index (Motyka's modification of the Sorenson index, Brower et al. 1990); to determine bird communities.

I took records of bird species occurrence by ear and by sight while sampling representative ecological plots over 120 Garry Oak areas (Figure 2). This was part of an ecological reconnaissance in 1993 and 1994, cov-

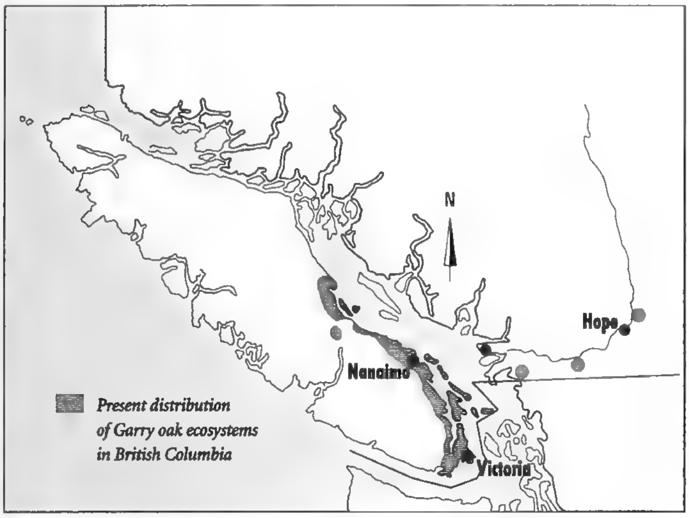

FIGURE 1. Garry Oak range in British Columbia. This map is courtesy of British Columbia Ministry of Water, Land and Air Protection, December 2003.

ering an area bounded by East Sooke, Gonzales Hill and Courtenay on Vancouver Island; and East Point, Saturna Island, and Helliwell Point, Hornby Island on the Gulf Islands (Erickson 1996). These locations are between approximately 48°N, 123°W and 49°30'N, 125°W. The Garry Oak stands sampled were primarily mature, but their canopy varied from shrub-like with exposure, to large and open on deep soils. Elevations ranged from sea level to about 550 m. Plots were approximately 200 m^2, consisted of relatively uniform vegetation and topography, and varied in size according to plant community boundaries. Species presence was recorded in an observation effort of approximately 90 minutes per plot. A total of 1243 records were taken on 286 plots (Erickson 2000b). Sampling was primarily in spring, during May and June. This time interval has migratory bird influx, spring vegetation growth, territory establishment, nesting, summer plant growth cessation and bird dispersal.

The data set had been previously checked with species accumulation curves (McCune and Mefford 1997; Erickson 2000b, unpublished data; Smith et al. 2002) to determine the adequacy of the sample. Occurrence by plot of all species with a frequency ≥5% for each year was entered into a data set; 23 species in 1993, and 29 species in 1994. This qualifying criterion reduced the number of plots to 135 in 1993 and 127 in 1994, for a total of 262 in the analysis. The DCA method uses chi-squared distances to simultaneously ordinate, in this case, bird species data against plots, and vice-versa. Axis solutions account for, and therefore represent the most variation in the data set. Bird species are separated and referenced by their scores relative to the detrended and re-scaled axes. Graphing the axis combinations provides a view of the reference coordinates in multivariate space. DCA is among the most widely used analytical methods in ecology (Peet et al. 1988). It has been applied in bird community work in oak woodland and other settings (Huff and Raley 1991; Pojar 1995; Garcia et al. 1998; Abernethy et al. 2001*; Parody et al. 2001).

In the interpretive graphing method I framed proportional circles on Axis 1 vs. 2, and Axis 1 vs. 3, on the DCA output graphs in order to outline potential bird groups. The circles represent four potential bird groups for each year's data, a number which was determined from species accumulation curve results. These

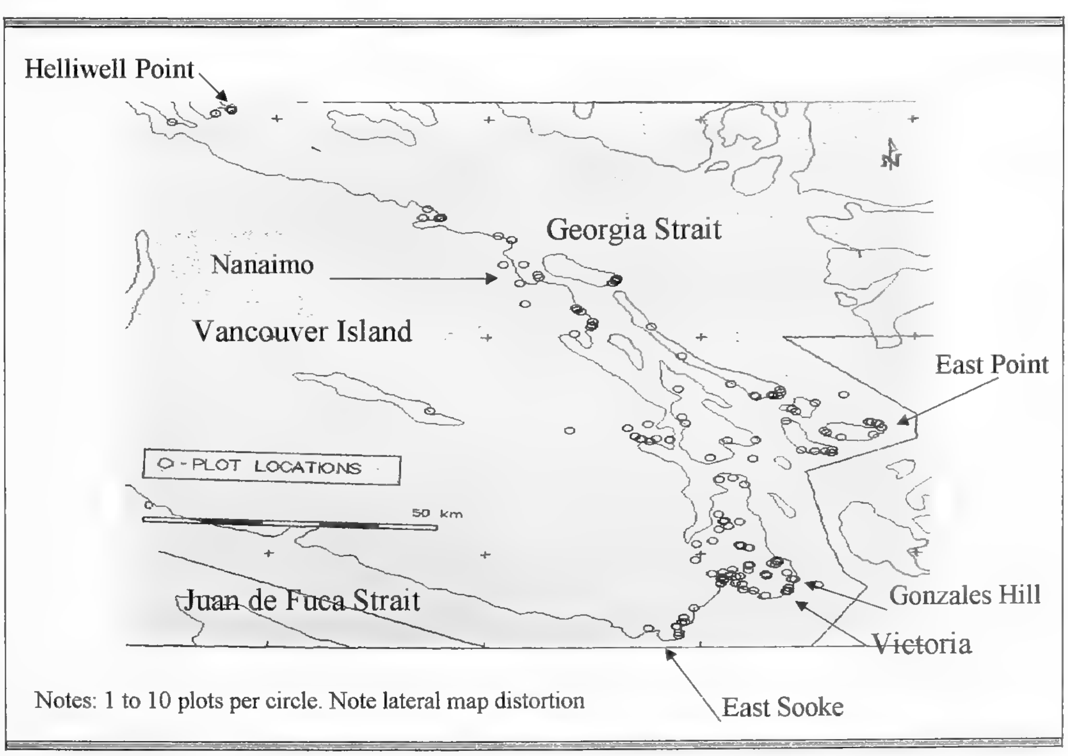

FIGURE 2. Garry Oak bird community sampling on Vancouver Island, British Columbia.

TABLE 1. Characteristic species classification.

Species classification	Symbol and similarity value	Association with a group on both axis combinations
Distinct	*d* (10)	unique to a group on both axis combinations
Companion	*c* (7)	unique to the group on one axis combination
Non differential	*n* (3)	distinct on one axis combination

results indicated that groups of approximately 35 plots could potentially cover >60% of the total species. The circles were centred on the graph coordinates from the median of the top-ranking species. Species rank was judged from the scores against each axis and the dominant axis combination (1 and 2) in the DCA result (Table 1, 2). These groups quantitatively represent the co-occurrence of species in different plots from the data, and they served as the first stage in identifying bird communities. Species were classified according to their distinctness to a group from the graphs and numeric values assigned (Table 1). Quantitative similarity index comparisons were then completed and the groups aggregated into communities based on the results.

Results

Species scores against the DCA axes are shown in Tables 2, 3 and 4. Four bird communities of Garry Oak habitat were identified by the analysis (Figures 3-6). Combinations of characteristic species, including most of the twenty top-ranking species in overall frequency, helped define the communities (Table 5). Characteristic species included American Goldfinch (*Carduelis tristis*), Spotted[1] Towhee (*Pipilo maculatus)*, Bewick's Wren (*Thryomanes bewickii*), Rufous Hummingbird (*Selasphorus rufus*) and Chestnut-backed Chickadee *(Poecile rufescens*) (community 1); House Wren (*Troglodytes aedon*), Olive-sided Flycatcher (*Contopus cooperi*), Purple Finch (*Carpodacus purpureus*), White-crowned Sparrow (*Zonotrichia leucophrys*), and Pine Siskin (*Carduelis pinus*) (community 2); Western Tanager (*Piranga ludoviciana*), Yellow-rumped Warbler (*Dendroica coronata*), American Goldfinch, Pine Siskin, Pacific-coast Flycatcher (*Empidonax difficilis*), Cassin's[1] Vireo (*Vireo cassinii*) and Chipping Sparrow (*Spizella passerine*) (community 3- 1993 only); and Northwestern Crow (*Corvus caurinus*) and European Starling (*Sturnus vulgaris*) (community 4- 1994 only).

Three groups had resulted in each of the two years, which were then reduced to the four communities. Two of these occurred across the years and two were unique to a single year. Communities were defined by the combination of their characteristic species. Similarity index values were quite low for the two across-year communities: 0.36 for community 1 and 0.43 for community 2. The two within-year communities had no similarity to each other (0 index value).

TABLE 2. Garry Oak bird species in 1993 with the highest scores against DCA axes, with median species designated*.

Species	Score
Axis 1:	
Northwestern Crow	522
Song Sparrow	499
California Quail*	388
Spotted Towhee*	388
Cedar Waxwing	388
Bewick's Wren	378
Axis 2:	
Cedar Waxwing	495
Pine Siskin	446
Bewick's Wren	400
Western Tanager*	388
Cassin's Vireo*	384
Yellow-rumped Warbler	384
California Quail	371
Song Sparrow	345
Axis 3:	
Chestnut-backed Chickadee	428
Rufous Hummingbird	336
Northern Flicker*	318
Pacific slope Flycatcher	294
Cedar Waxwing	275

TABLE 3. Garry Oak bird species in 1993 and 1994 with the highest scores against DCA axis combination 1 and 2, with median species designated*.

Year and Species	Score	Score
1993	axis 1	axis 2
California Quail	388	371
White-crowned Sparrow	183	250
Olive-sided Flycatcher*	119	230
American Goldfinch	302	342
House Wren	69	135
1994		
Brown Creeper	222	230
Rufous Hummingbird	406	275
Brown-headed Cowbird*	373	262
Northern Flicker*	258	426
Pacific-slope Flycatcher	216	162
Cassin's Vireo	254	224

Note: The former common names (Common Flicker, Rufous-sided Towhee, Common Starling, and Solitary Vireo) were used in the data and Figures for Northern Flicker, Spotted Towhee, European Starling and Cassin's Vireo.

[1] The former common names, (Common Flicker, Rufous-sided Towhee, Common Starling, and Solitary Vireo) were used in the data and Figures 1-4 for Northern Flicker, Spotted Towhee, European Starling and Cassin's Vireo.

TABLE 4. Garry Oak bird species in 1994 with the highest scores against DCA axes, with median species designated*.

Species	Score
Axis 1:	
Song Sparrow	583
Northwestern Crow*	460
European Starling*	420
Rufous Hummingbird	406
Axis 2:	
Common Flicker	426
White-crowned Sparrow	401
Song Sparrow*	294
Chipping Sparrow	283
Rufous Hummingbird	275
Axis 3:	
European starling	506
Violet-green Swallow	396
Olive-sided Flycatcher*	378
House Wren*	358
White-crowned Sparrow	327
Spotted Towhee	326

Note: The former common names (Common Flicker, Rufous-sided Towhee, Common Starling, and Solitary Vireo) were used in the data and Figures for Northern Flicker, Spotted Towhee, European Starling and Cassin's Vireo.

The overall frequency (Erickson 2000b) of these characteristic species gives an indication of the abundance of the communities. Community 1 was most frequent, with the #3-rank Spotted Towhee; the #4 Chestnut-backed Chickadee; #6 American Goldfinch; #14 Bewick's Wren and #16-rank Rufous Hummingbird. Community 2 had the #5-rank White-crowned Sparrow; #10 House Wren; #12 Pine Siskin; #13 Olive-sided Flycatcher; and the #19-rank Purple Finch. Community 3 had the #6-rank, American Goldfinch; #7 Pacific-coast Flycatcher; #11 Chipping Sparrow; #12 Pine Siskin; #18 Yellow-rumped Warbler; #21 Cassin's Vireo; and #24-rank Western Tanager. Community 4 had the #15 rank Northwestern Crow and the #26 rank European Starling.

Discussion

Sampling and analysis

Communities are differentiated here by their visual distinctness in the multivariate space defined by bird frequency and composition, and by differences defined using thresholds in quantitative index of similarity comparisons. Both measures use quantity along with composition, which ensures that the communities arising from the data are actually different from each other. Although eigenvalues can measure the overall strength of a multivariate relationship, such as the multivariate coefficient of variation for each axis in an ordination, they are not a test statistic in Detrended Correspondance Analysis.This method uses detrending and rescaling to avoid the spurious, secondary arch effect of previous techniques, but this in turn prevents the use of eigenvalues. Although the differences by year were significant for many species in previous t-test comparisons (Erickson, unpublished data), these tests are not used here, as they are not appropriate for analysis of non-experimental survey data (e.g., Hurlbert 1984).

Sampling occurred on discrete but much smaller (0.02 ha) plots in this study than in many others. How-

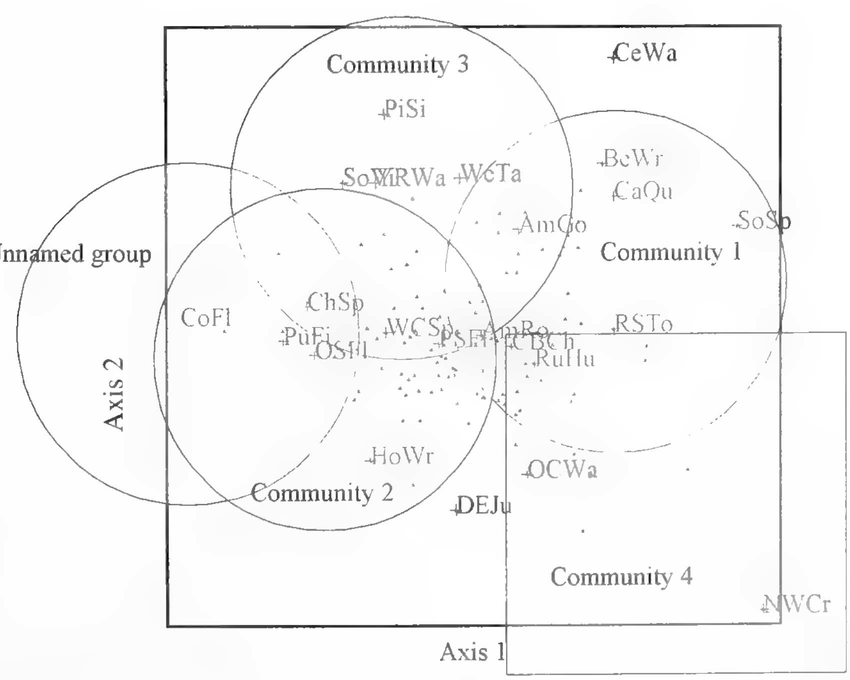

FIGURE 3. Garry Oak bird communities from DCA analysis of 1993 data, Axis 1 vs. 2. Large square represents the multivariate space formed from the data centred on the DCA axes. Circles are objectively defined groups or communities. Small square is a subjectively placed community. Bird species coordinates are marked by a cross and designated by the first letters of the common name (former names as noted in the text). Other data points are the plot coordinates.

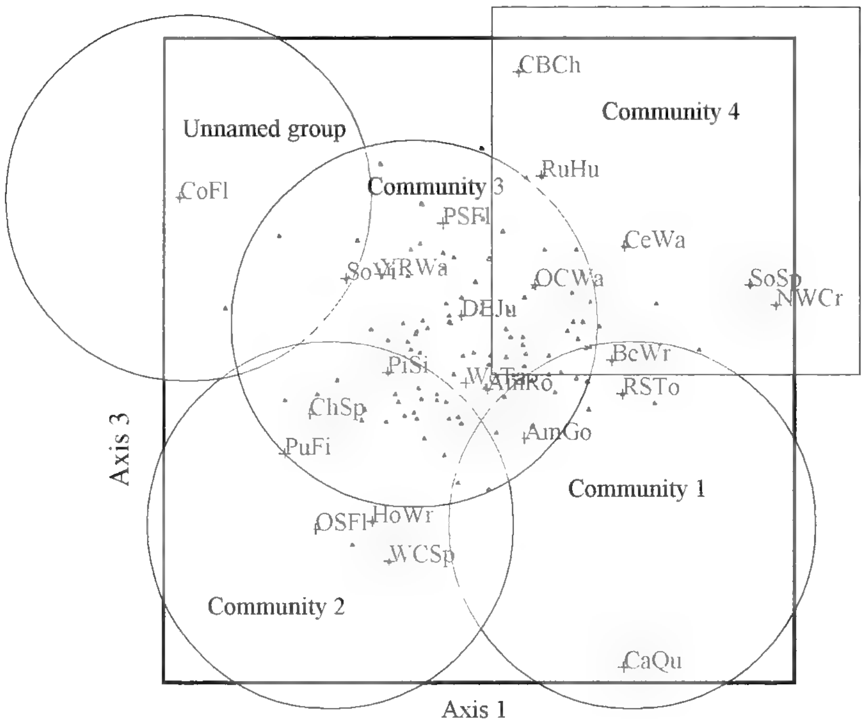

FIGURE 4. Garry Oak bird communities from DCA analysis of 1993 data, Axis 1 vs. 3. Large square represents the multivariate space formed from the data centred on the DCA axes. Circles are objectively defined groups or communities. Small square is a subjectively placed community. Bird species coordinates are marked by a cross and designated by the first letters of the common name (former names as noted in the text). Other data points are the plot coordinates.

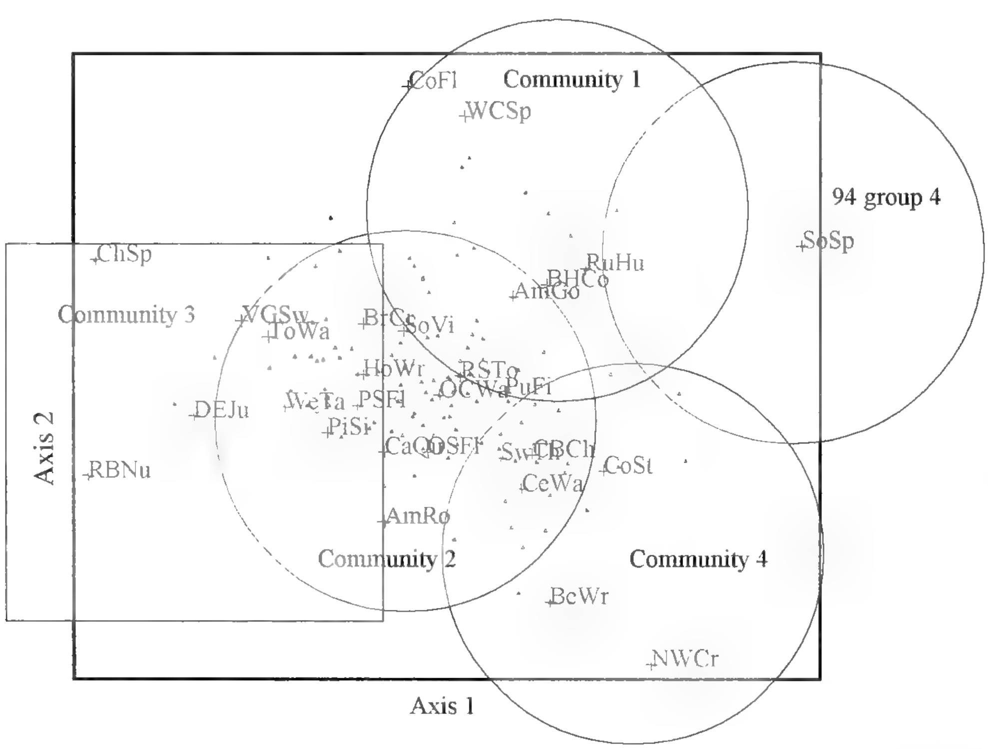

FIGURE 5. Garry Oak bird communities from DCA analysis of 1994 data, Axis 1 vs. 2. See explanation for Figure 4.

ever, the number of plots was correspondingly larger (262 plots) and records were taken over a much longer observation period (90 minutes per plot) than in many studies. Consequently, the results do not represent extreme low values in comparison to studies using other methods in oak woodlands. In my species accumulation curves, about one half the species were covered by 15 randomly selected plots, and three-quarters of the species by 45 plots (Erickson 2000a).

The average number of species detections per plot (3.7, 1993; 5.0, 1994; Erickson 2000a) is from the same order of magnitude for two count periods (3 species, 5 species per 0.28 ha plot) in Jalisco, Mexico, oak woodland; but lower than two other count peri-

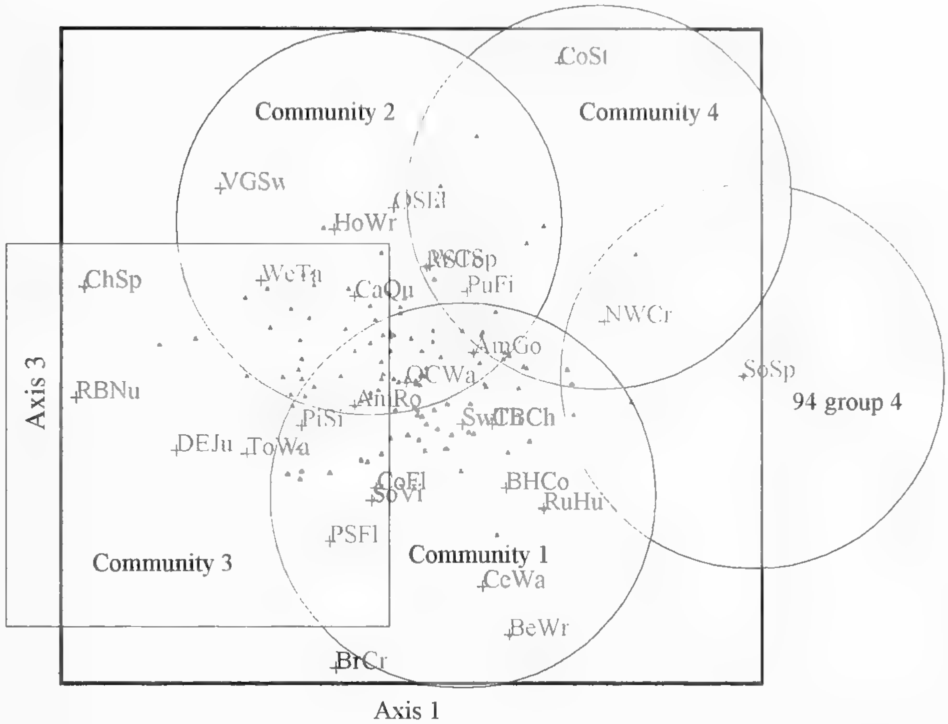

FIGURE 6. Garry Oak bird communities from DCA analysis of 1994 data, Axis 1 vs. 3. See explanation for Figure 4.

ods (10, 12 species: Corcuera and Butterfield 1999). My averages were much lower than those recorded on multiple plot, large-area studies: 21 to 25 late-spring species on five, 70 to 130 ha, stands in Oregon (Anderson 1970), and 9 to 29 breeding species from 40 ha oak census plots in Pennsylvania (Probst 1980). My total number of species detections (66) is higher than in a number of studies in oak woodland (e.g., 38 species in Dedon et al. 1984; 20 to 62 species in Leidolf et al. 2000; 43 to 51 species in Stone no date*; 50 and 58 species in each of two seasons, five forest types, Corcuera and Butterfield 1999) but is lower than in some other comparable results (e.g., 77 species in Garcia et al. 1998). My total would be increased by an additional 12 species which I recorded as "out of plot", "out of habitat", or "overhead". However, much of this difference is irrelevant, in that my interest in defining bird communities was at the plot (not area) level, and was focused on frequently occurring species which are easily detected within my plot parameters, not on less common species used to round out a full species list.

The graphical location method is an objective one, in its centering technique and the proportional allocation of multivariate space to each community. Unbiased shapes, such as squares or circles, were used to define multivariate species aggregations and overlap in composition was accepted. Other methods include subjective ones (e.g., Pojar 1995), and other objective approaches, such as the use of a "fuzzy-clustering partition coefficient" (Abernethy et al. 2001*). These methods tend to result in elliptic forms, irregular boundaries and volumes of multivariate space, and no overlap in composition. The elliptical forms assume a trend in dimensionality that does not actually occur with the DCA methodology, as it has demonstrated potential to produce evenly distibuted sample points in multivariate space (Peet et al. 1988).

Communities

Of the six groups first resulting from the DCA analysis, two from each year were similar enough (similarity index > 0.33) to combine. One group from 1994 was dropped because it had less than my conceptual threshold of three species. Two within-year communities were not differentiated by the results of the other year, but it was possible to represent them subjectively. To do so, I placed the square frame (Figures 3-6) on the graphs of the other year, and in doing so, included species and multivariate space not already covered. Through this process, Dark-eyed Junco (*Junco hyemalis*) was added to community 3 as a distinct species in 1994, although in 1993 it was limited to one of the two one-axis combinations. The two top-ranking species in frequency, Orange-crowned Warbler (*Vermivora celata*) and American Robin (*Turdus migratorius*) did not contribute to the characteristic combination of species for the communities. American Robin did qualify as a characteristic species, but was not used because it was in three out of four communities.

Consideration was given to dropping another group which occurred only in 1994, as it had only two distinct species, Northwestern Crow and European Starling. However, it was kept (as Community 4) because these two species are potentially important as ecological indicators. They may both signify a disturbance zone and represent a source of disturbance themselves, via nest predation and nest cavity competition. In addition, this community can be characterized by the absence of other species. There may be an inversely

TABLE 5. Bird communities and characteristic species of Garry Oak habitat.

Species	Group					
	93-1	94-3	93-3	94-2	93-2	94-1
Community 1						
American Goldfinch	c	c		c	c	
Spotted Towhee	d	n		c		n
Bewick's Wren	d	n				n
Rufous Hummingbird	n	d				
Chestnut-backed Chickadee	n	n		n		n
Community 2						
House Wren			d	d		
Olive-sided Flycatcher			c	d		
Purple Finch		n	c	c		n
White-crowned Sparrow		n	c	n		n
Pine Siskin		n	n	n	c	
Community 3						
Western Tanager				d	d	
Yellow-rumped Warbler					d	
Pacific-slope Flycatcher				n	c	
Cassin's Vireo					c	
Chipping Sparrow				c	c	
Dark-eyed Junco*					n	
Community 4						
European Starling						d
Northwestern Crow						d
Other species:						
Song Sparrow	n					
California Quail	d			d		
Violet-green Swallow				d		
Orange-crowned Warbler		n		c		
Townsend's Warbler				n		
Brown Creeper				n		
Cedar Waxwing		n		n		n
Swainson's Thrush		n		n		n
Common Flicker			n			
American Robin	n	n	n	c	c	

Notes: Communities are shown in the boxes. See Table 1 for species classification codes. The addition of Dark-eyed Junco to community 3 is partly subjectively derived.

proportional relationship to the presence of Northwestern Crow and European Starling across various sites. In this study, the lack of importance of another disturbance indicator, Brown-headed Cowbird (*Molothrus ater*), contrasts with the high numbers of cowbird nestlings on two Garry Oak sites west of Victoria, British Columbia (Shepard 2000). However, the present results reflect only detections of adults and fledged birds in a reconnaissance investigation.

Cross-year similarity index values were relatively low, approximately one-half of my expected threshold value of 0.66. Therefore I considered using the concept of assemblages to denote a weaker level of association. However, both the terms community (e.g., Huff and Raley 1991; Pojar 1995; Garcia et al. 1998; Abernethy et al. 2001*; Parody et al. 2001) and assemblage (e.g., Manuwal 1986; Corcuera and Butterfield 1999; Hagar and Stern 2001) receive only general use in the literature, and the term community is referred to more widely. The year differences I encountered could relate to increases in bird frequency and dominance shifts in 1994, possibly linked to yearly weather (Haila et al. 1993; Erickson 2000b).

The communities may differ in the life history traits of their characteristic species, as shown in Table 6 (Leidolf et al. 2000; Ehrlich et al. 1988), and therefore in their general habitat and guild use. Species of community 1 have mixed nest locations and most are insectivorous when on breedng territory. Those of community 2 have an equal dominance of granivores with insectivores. Most species of community 3 forage in shrubs and trees. Community 4 species are tree-nest-

TABLE 6. Life history traits for characteristic species of Garry Oak bird communities.

Community and species	Nest Location	Foraging Layer	Foraging Method	Food Type
Community 1:				
American Goldfinch	SH	HB/ SH/ TR	FG	GV
Spotted Towhee	GR/ SH	GR	GG	IN/ OM
Bewick's Wren	TR	GR	GG	IN
Rufous Hummingbird	VN/ TR	HB	HG	NE
Chestnut-backed Chickadee	SN	SH/ TR	BG	IN
American Robin	SH/ TR	GR/ SH/ TR	GG/FG	IN/ FR
Community 2:				
House Wren	TR	GR	GG	IN
Olive-sided Flycatcher	TR	AIR	HA	IN
Purple Finch	TR	GR	GG	GV
American Robin	SH/ TR	GR/ SH/ TR	GG/ FG	IN/ FR
White-crowned Sparrow	SH	GR	GG	GV
Pine Siskin	TR	HB/ SH/ TR	FG	GV
Community 3:				
Western Tanager	TR	SH/ TR	FG	IN
Yellow-rumped Warbler	TR	SH/ TR	FG	IN
American Goldfinch	SH	HB/ SH/ TR	FG	GV
American Robin	SH/ TR	GR/ SH/ TR	GG/FG	IN/ FR
Pine Siskin	TR	HB/ SH/ TR	FG	GV
Pacific-slope Flycatcher	TR	AIR	HA	IN
Cassin's Vireo	TR	SH/ TR	FG	IN
Chipping Sparrow	SH/ TR	GR	GG	IN/ GV
Dark-eyed Junco	GR	GR	GG	GV
Community 4:				
Northwestern Crow	TR	GR	GG	OM
European Starling	TR	GR	GG	IN

Note: Nest location: TR-tree, VN-vine; GR-ground, SH-shrub, SN-snag. Foraging Layer: AIR-air, GR-ground, HB-herb, SH-shrub, TR-tree. Foraging Method: BG-bark glean, FG-foliage glean, GG-ground glean, HA-hawk, HG-hover and glean. Food Type: FR-frugivore; GV-granivore; IN-insectivore; NE-nectarivore, OM-omnivore.

ing ground gleaners. Shared traits are as follows: tree nesting insectivores (community 2,3) and ground gleaning (1,2,4). The comparison may suggest general habitat and guild relationships for the communities. This could include open savanna settings (community 2,4) and shrubby woodlands or shrub oak (community 1,3). More work is needed on habitat relationships though.

Comparison with other studies

In this study, bird communities have been delineated within the Garry Oak habitat at a detailed level by aggregations of the bird species themselves. This approach is not typical in the literature. There are indications of different bird communities in the discussion of Hagar and Stern (2001) for Garry Oak woodlands, including Chipping Sparrow as a species of semi-open woodland and Orange-crowned Warbler as shrub-associated. Dedon et al. (1984) employed habitat suitability class lists, possibly comparable to more detailed communities, in California Black Oak (*Quercus kelloggii*) habitat. One shrub community was identified to subdivide Gambel Oak (*Quercus gambellii*) woodlands (Stone no date*) in Colorado. Artman et al. (2001) found in Ohio that differences in bird communities within mixed oak forests could be related to three moisture index classes. Pojar (1995) described separate bird communities within Trembling Aspen forests of north-central British Columbia.

In most oak woodland bird studies, bird communities have been identified at a more general level. Broad habitat groupings have formed bird communities, guilds have been separated by shared traits, or communities have been grouped by successional stages (e.g., Anderson 1970; Smith 1977; Probst 1980; Davis et al. 2000; Hagar and Stern 2001). Both Leidolf et al (2000) and Stone (no date*) described bird communities associated with four different Gambel Oak habitats (i.e., oak woodland, submontane shrub, Ponderosa Pine (*Pinus ponderosa*)/oak woodland, and mixed conifer/oak woodland), and locations. Garcia et al. (1998) and Corcuera and Butterfield (1999) referred to separate bird communities in oak woodlands, mixed oaks (*Quercus rugosa, Q. candicans, Q. obtusata, Q. laurina*) and other groupings for north-central Michoacan, Mexico.

Some comparisons and comments can be made about the composition of communities from the present study in relation to these others. Shepard (2000) outlined the importance of House Wren (found in community 2) for two Garry Oak sites west of Victoria,

British Columbia. However, those sites had steady numbers of Red-breasted Nuthatch (*Sitta canadensis*) and Brown Creeper (*Certhia americana*), species which were unimportant in the present study. Most of the frequent birds from my study were present in Black Oak habitat in northern California, but no more than one or two species were listed by habitat suitability class (Dedon et al. 1984). Five of the seven species of community 3 were resident or breeding species in the ponderosa pine/Gambel Oak forest in north-central New Mexico (Leidolf et al 2000). The two remaining species are not found in the range of Gambel Oak. However, the shrub subdivision in Gambel Oak bird communities (Stone no date*) is not similar to the four communities except for the presence of Spotted Towhee. A community from Trembling Aspen forests in north-central British Columbia had similarities (4/7 species) to community 3 (Pojar 1995). Although this was labelled a group of conifer-related species, three of four species were associated with Gambel Oak and Trembling Aspen in southwestern Colorado (Stone no date*). In addition, Shepard (2000) mentioned high densities of Pacific-slope Flycatcher, also a species of community 3; and the importance of Chesnut-backed Chickadee (found in community 1), for two Garry Oak sites in British Columbia. These species have similarly been thought of as conifer (Douglas-fir)-related (Huff and Raley 1991). Neither the other two Trembling Aspen bird communities (Pojar 1995), nor the ones described for Douglas-fir habitat (Shepard 2000; Huff and Raley 1991) had any substantial similarity to the four communities in the present study.

Summary

Testing of wildlife habitat relationship models based on broad habitats (e.g., oak woodland, old-growth Douglas-fir forest) has given results which questioned their basic utility (e.g., Dedon et al. 1984; Laymon 1989). This suggests that other methods could be examined. An alternative approach, which empirically defines spatial and temporal bird aggregations as bird communities, is presented here, and may warrant further investigation.

The four communities identified in this work could serve as benchmarks in Garry Oak ecosystem studies. Like any classification, they should be tested with further field work and analysis, particularly for differentiation by habitat features. For example, Erickson and Campbell (2001) related correlations involving moisture regime, oak diameters, tree form complexity, total wildlife habitat features, and, for one year, average number of bird species per plot. Monitoring is recommended as a first step in maintaining characteristic Garry Oak bird communities, a focus which should parallel growing concern for this endangered habitat and contribute to increasing conservation efforts.

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Invertebrate Diversity under Artificial Cover in Relation to Boreal Forest Habitat Characteristics

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We investigated invertebrate diversity in boreal forests using an experimental design that consisted of counting soil invertebrates under artificial cover. The aim was to assess the utility of using soil invertebrate diversity as a measure of ecosystem health. The study area was grouped into five habitats: upland hardwood, lowland hardwood, conifer, shrub, and conifer-grass. Simpson's and Shannon's indices of invertebrate diversity were negatively correlated with percent herbaceous cover. Number of recognizable taxonomic units (RTU richness) was negatively correlated with percent litter cover. The number of individual invertebrates was positively correlated with soil moisture and negatively correlated with percent conifer cover. Invertebrate diversity varied among habitat types, with conifer forests (spruce, fir, pine) having the highest diversity and regenerating conifer-grass forests having the lowest diversity, suggesting that successional stages affect diversity. The most productive sites, upland and lowland hardwood habitats, had the highest abundance of soil invertebrates, although intermediate diversity compared to the other five habitats. The results are consistent with the view that diversity increases and then decreases with productivity and disturbance over succession (ca. 50-100 yr). Hence, maintenance of soil invertebrate diversity in managed boreal forests requires the provision of a varied landscape with a mosaic of disturbance regimes.

Key Words: arthropods, biodiversity, conifer, earthworms, indices of diversity, moisture, Ontario.

Concerns about the effects of the widespread loss of biodiversity have prompted many recent studies investigating the relationship between biodiversity and ecosystem function (Symstad et al. 2000). Invertebrates are important in the functioning of nearly all environments, with changes in species composition potentially reflecting changes in the ecosystem (Majer 1990; Madden and Fox 1997). Hence invertebrates are increasingly being viewed as reliable indicators to assess human impacts on the general level of disturbance of an ecosystem (Majer 1983; Greenslade 1984; Andersen 1990). Biodiversity includes all levels of natural variation and thus diversity indices provide a relative measure of variation within a community (Tilman and Pacala 1993). Monitoring diversity across spatial and temporal scales allows for measurement of system complexity, functionality, and stability. Knowledge of diversity helps in understanding changes in ecosystem complexity before and after disturbance. Information on the habitat characteristics that influence diversity at various levels and knowledge of habitat changes resulting from human disturbance are required for management and conservation (Madden and Fox 1997).

Forest managers can assess diversity changes associated with human disturbances that include various forestry practices through an understanding of the relationship between animal diversity and forest structure to determine ecosystem changes (Noss 2000). Animal diversity includes soil invertebrates commonly found under logs and rocks in managed forests (Kolstrom and Lumatjarvi 1999). Downed wood is important for organisms in providing shelter and moisture, and in preventing light penetration. The use of soil fauna diversity has the potential to act as a surrogate of forest biodiversity. A number of forest characteristics have been shown to relate to soil invertebrate diversity, including understorey vegetation and litter (Bird et al. 2000), plant functional diversity (Siemann et al. 1998), coarse woody debris (Marra and Edmonds 1998), conifer species composition (Lattin 1993), forest succession (Paquin and Corderre 1997), soil moisture (MacKay et al. 1986) and structural complexity (Ferguson 2001).

To further this research, we used a method of surveying invertebrate diversity under artificial cover and relate indices of invertebrate diversity to measured forest characteristics. The study design consisted of (1) surveys of soil invertebrates (springtails, beetles, centipedes, slugs, earthworms and isopods) found under sand-filled cardboard boxes placed on the forest floor; and (2) surveys of the sampled forest characteristics (snags, logs, soil moisture, overstorey, understorey, and ground cover). Forest characteristics were used to identify habitats within a boreal forest landscape, and diversity of soil invertebrates was measured. The goal was to relate forest habitat characteristics to soil invertebrate diversity to assess their utility as surrogate measures of ecosystem changes associated with forest management practices.

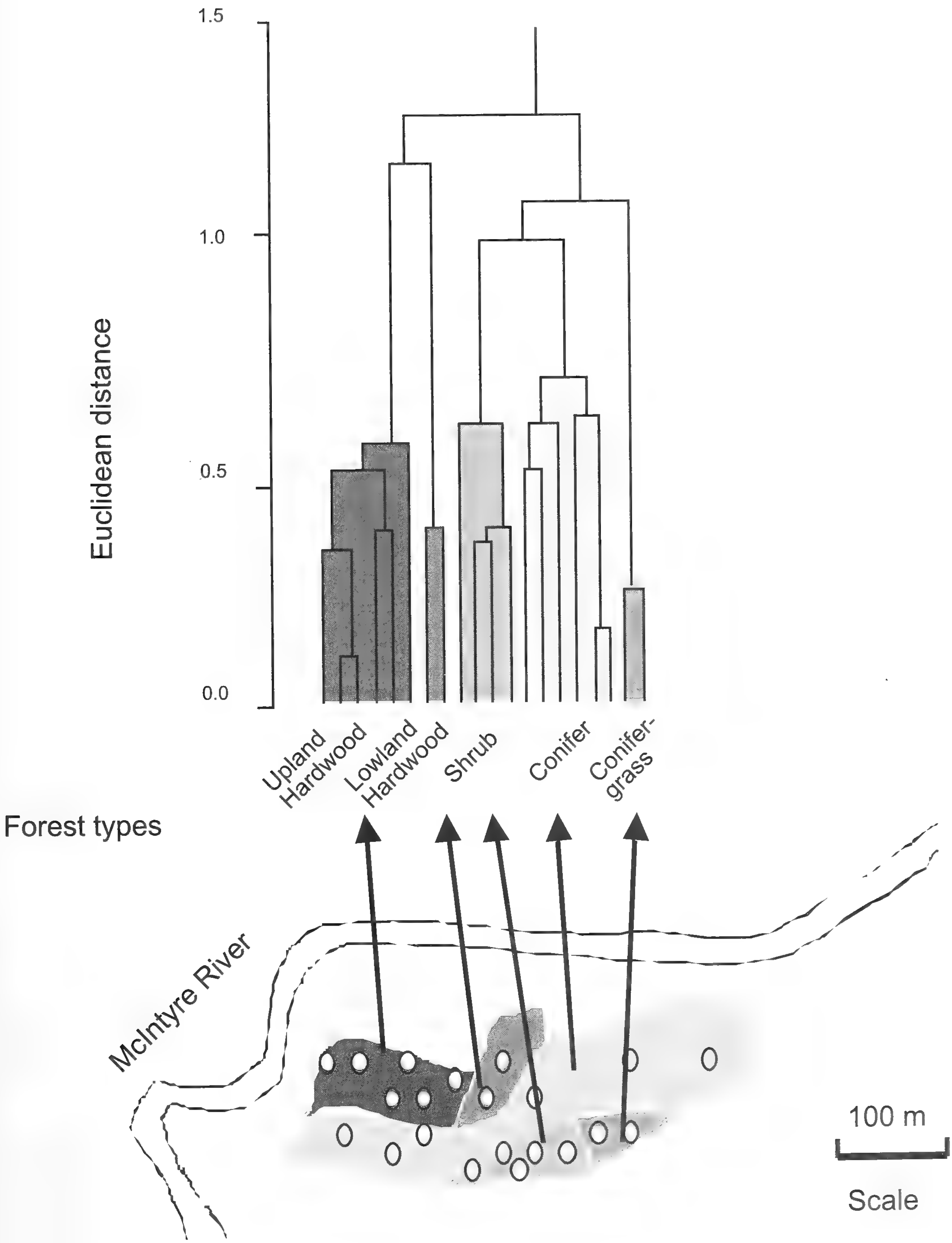

FIGURE 1. Location of study area in northwestern Ontario and dendrogram of 20 plots (0) located within a 1 km^2 stand of boreal forest grouped using cluster analysis based on forest characteristics (e.g., overstorey, understorey, ground cover, moisture, coarse-woody debris).

Study Area

The study area (Figure 1) was located in northwestern Ontario, Canada, and consisted of a 1 km^2 area of boreal forest located along the McIntyre River within Lakehead University's natural forest (48°22'N, 89°19'W). The mixed boreal forest consisted of Jack Pine (*Pinus banksiana* Lamb.), Black Spruce (*Picea mariana* (Mill.) B.S.P.), Balsam Fir (*Abies balsamea* (L.) Mill.), White Spruce (*P. glauca* (Moench) Voss), White Birch (*Betula papyrifera* Marsh.), and Trembling Aspen (*Populus tremuloides* Michx.). The study site lies within the Boreal Ecosystem that consists of rolling rocky uplands with coarse well-drained soils (Rowe 1972). The climate is humid continental with a mean minimum January air temperature of -15°C and a mean maximum daily air temperature for July of 18°C (Environment Canada 2001*). Mean annual precipitation is approximately 700 mm, including a mean winter snowfall of 196 cm (Environment Canada 2001*). For the study period (May to September), mean monthly daily air temperature (1961-1990 normals) varied from 9.0°C in May to 17.7°C in July (annual mean = 2.4°C) and precipitation varied from 69.3 mm in May to 88.5 mm in August (annual mean = 58.6 mm) (Environment Canada 2001*).

Methods and Materials

Study design and sample plots

The sampling method was designed to assess soil invertebrate diversity under a standardized collection technique that optimized sampling replication, effort, and coarse taxonomic resolution. Coarse woody debris occurred in various shapes, sizes, and material. The use of cardboard boxes standardized the collection and reduced this variability while sampling a more diverse fauna than other methods such as pitfall traps. We decided to use a coarse taxonomic resolution (Bolger et al. 2000), thereby allowing inexperienced observers with minimal training to obtain reasonable survey counts efficiently. A trade-off associated with grouping invertebrates occurs between ease of surveys by observers with minimal taxonomic experience and the loss of more detailed guild and life history information related to individual species.

Twenty plots, each consisting of three adjacent boxes, were randomly distributed within the forest (minimum distance between plots was 5 m; Figure 1). Each box consisted of two 2-liter milk cartons with a plastic coating of red and white color. These were fitted one inside the other to create a solid box and filled with sand (approximately 2 kg) to create a footprint-sized depression 21 by 9.5 cm. Boxes depressed the leaf litter an average of 1.3 cm (Ferguson 2000), creating a microhabitat of increased humidity and decreased temperature similar to that beneath a log or rock resting on the forest floor.

Boxes were overturned and the numbers of all soil invertebrates (>1 mm) were visually counted. Boxes were lifted individually without disturbing adjacent boxes or the underlying litter. Twenty weekly surveys were conducted from 9 May to 24 September 2000 between the hours of 1100 to 1700. The survey numbers reflect a relative abundance of soil invertebrates. Observer bias was consistent across the landscape.

Recognizable Taxonomic Units (RTU; Bolger et al. 2000; Ferguson 2004) were used to group all macroinvertebrates (>3 mm) observed under boxes based on differences in size and feeding habits (Eisenbeis and Wichard 1987; Brock et al., 1994) and included springtails (Collembola), spiders (Araneae), ants (Formicidae), ant larvae, centipedes (Chilopoda), Diplura, adult flies (Diptera), phytophagous mites (Acarina: Oribatida), bugs (Hemiptera and Homoptera), Pseudoscorpionida, wasps (non-ant Hymenoptera), moth and butterfly larvae (Lepidoptera), Gastropoda (snails and slugs), Isopoda (woodlouse; *Tracheoniscus rathkei*), beetles (Coleoptera and Staphylinidae species – adults and larvae), millipedes (Diplopoda), and earthworms (Oligochaeta).

Forest characteristics measured

Site-specific habitat variables were measured 21-23 August 2000 using 5 × 5 m quadrats centered at three box plots. One quadrat was located at the centre of each plot. Four other quadrats were located 10 m from the centre in cardinal compass directions. A total of 100 quadrats were sampled for the following habitat characteristics: percent overstorey cover (>5 m), percent understorey cover (saplings and shrubs 0.5-5 m), percent herbaceous cover, percent litter cover, percent grass cover, percent moss cover, percent fern cover, number of snags (dead standing trees with dbh > 5 cm), number of decaying logs (> 5 cm diameter), percent cover by conifers, and a relative measure of soil moisture (i.e., xeric=1, mesic=2, hydric=3). Values for the five quadrats were averaged for each plot.

Measures of invertebrate diversity

Diversity of soil invertebrates was calculated for each plot across surveys using RTU richness (number of RTU at each site), Shannon-Wiener, and Simpson's Indices of Diversity (Ludwig and Reynolds 1988). Shannon's entropy (H) is a measure of species diversity used in relation to relative frequencies (probabilities) of the different species i of the sample and was calculated as:

$$H = - \sum [(n_i/n) \ln(n_i/n)] \text{, from } i=1 \text{ to } n \qquad (1)$$

where n_i is the number of individuals belonging to the ith RTU in the sample and n is the total number of individuals in the sample. $H = 0$ (minimum value) when the sample contains only a single RTU, whereas diversity H increases with the number of RTUs. H is maximum when all RTUs are equally distributed in the sample. The Shannon-Wiener index of diversity is sensitive to changes in the rare species in a community sample (Pielou 1966). Invertebrate diversity was also measured by Simpson's index of diversity (Simpson 1949), which is sensitive to changes in the more abundant species and was measured as:

$$\lambda = 1- \sum n_i(n_i - 1)/n(n - 1) \qquad (2)$$

Simpson's index varies from 0 to 1, and gives the probability that two individuals drawn at random from a population belong to the same RTU. If the number approaches 0 then individuals belong to the same RTU and the diversity of the community sample is low. These diversity measures were calculated using the minimum number of invertebrates observed for the RTU in a given sampling period and were represented by an average value for each survey.

Statistical analysis

We performed a cluster analysis of the 11 forest measures to group the 20 sampling sites into forest habitats. Classification of habitats types was conducted by the average-linkage clustering method using a Euclidean distance similarity index (Romesburg 1984). All variables were standardized between 0 and 1.

Many (8 of 17) forest and soil invertebrate variables were not normally distributed (Wilk's statistic) and transformations (e.g., log, arc-sine) failed to normalize all variables. Therefore, we used nonparametric analyses by ranking nonparametric data before correlation analyses (Conover and Iman 1981). Measures of diversity (Simpson's and Shannon's), RTU richness, and number of individuals were normally distributed and did not require transformations. We report untransformed means in the Figures and Tables in the Results section to simplify presentations.

Analyses were performed to determine the relationship between (1) soil invertebrate diversity indices and forest characteristics, and (2) soil invertebrate numbers for each of the abundant RTU (springtails, beetles, centipedes, slugs, earthworms, and isopods) and forest characteristics. We tested for significant effects of forest characteristics on dependent measures (e.g., diversity) with Spearman's correlations and partial correlation analyses (i.e., multiple regression of ranked data without replacement). ANOVA was used to compare forest characteristics, indices of diversity, and soil invertebrate abundance relative to forest types, followed by a Tukey multiple range test if the ANOVA was significant. Spearman correlations for nonparametric data and Pearson's correlations for parametric data compared RTU abundance with forest characteristics. Sample units were the 3-box groups (n = 20) sampled every week (n = 20). All statistical analyses were done using SAS (SAS Institute Inc., Cary, North Carolina 1987) statistical software for microcomputers.

Results

Both indices of soil invertebrate diversity (Shannon's and Simpson's) were negatively related to percent herbaceous cover ($R^2 = 0.32$, $F = 5.89$, $P = 0.01$, $n = 20$ and $R^2 = 0.35$, $F = 6.64$, $P = 0.01$ respectively; Table 1, Figures 2A, and 2B). RTU richness (number of RTU) was negatively correlated with percent litter cover, which explained 48.6% of the variance in the model ($F = 17.0$, $P = 0.001$, $n = 20$; Table 1, Figure 2C). Diversity indices were also related to litter cover as herbaceous cover and litter cover covaried ($r = -0.94$). Soil moisture (69.5% of variation explained) and percent conifer cover (9%; Figure 2D) best explained the number of individual invertebrates. Greater numbers of soil invertebrates occurred in wet habitats and with less conifer cover (Table 1).

The forest measures were grouped into five forest types defined as upland hardwood, lowland hardwood (mesic), shrub, conifer, and conifer-grass (Figure 1). The upland hardwood forest consisted primarily of Trembling Aspen, with little understorey (47% cover) and the most abundant herbaceous cover (90%; Table 2). The soil invertebrate community in the upland hardwood forest consisted of numerous individuals (mean = 24/plot), moderate RTU diversity, and large numbers of isopods (Table 2). The lowland hardwood habitat consisted of mixed hardwoods in a mesic site that included an intermittent stream with a deep humus layer. The soil invertebrate community

TABLE 1. Seven multiple regression results used to determine the significant effects of 11 forest characteristics on (1) Shannon's index of diversity; (2) Simpson's index of diversity; (3) RTU richness (where RTU = recognizable taxonomic units); (4) Number of individual invertebrates, (5) springtail abundance; (6) earthworm abundance; (7) isopod abundance. Of the 11 explanatory variables included (soil moisture, % overstorey, % understorey; % herb cover; % litter; % grass; % moss; % ferns; number of snags; number of logs; and % conifer cover), only those with significant ($P < 0.05$) relationships are shown.

Dependent variable	Independent variable	Coefficient direction	Partials R^2	Model R^2	P
(1) Shannon's diversity index	% herb cover	negative	0.318	0.318	0.008
(2) Simpson's diversity index	% herb cover	negative	0.349	0.349	0.006
(3) RTU richness	% litter cover	negative	0.486	0.486	0.001
(4) Number of RTU	Soil moisture	positive	0.695	0.695	0.0001
	% conifer cover	negative	0.087	0.782	0.02
(5) Springtail abundance	% conifer cover	negative	0.224	0.224	0.04
(6) Earthworm abundance	Conifer cover	negative	0.657	0.657	0.0001
	Number of logs	positive	0.100	0.757	0.02
(7) Isopod abundance	% conifer cover	negative	0.624	0.624	0.0001

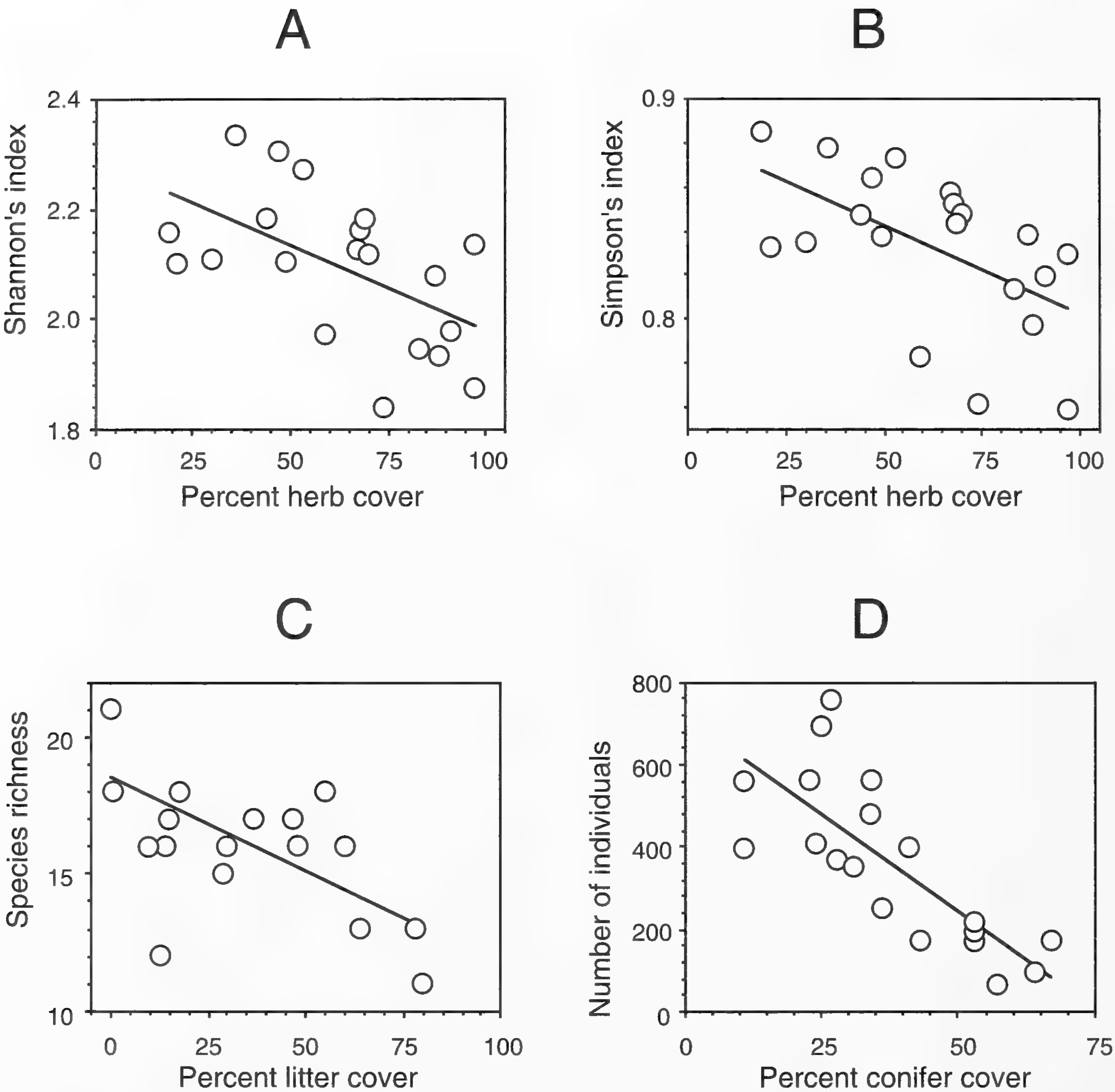

FIGURE 2. Bivariate relationships between two indices of diversity (Simpson's and Shannon's) of soil invertebrates and major explanatory habitat variables: (A) Shannon's index of diversity, and percent herbaceous cover ($y = -0.307x + 2.29$, $r^2 = 0.318$); (B) Simpson's index of diversity and percent herbaceous cover ($y = -0.0810x + 0.883$, $r^2 = 0.349$); (C) RTU richness (number of Recognizable Taxonomic Units) and percent litter cover ($y = -0.0692x + 18.6$, $r^2 = 0.486$); and (D) number of individual invertebrates and percent conifer cover ($y = -9.38x + 712$, $r^2 = 0.695$).

living in this forest consisted of moderate diversity, the greatest number of individuals (mean = 37/plot), and the most springtails and earthworms. The shrub habitat had the highest understorey cover (78%), lowest overstorey (34%), and moderate conifer and litter cover. The soil community in the shrub habitat was moderately diverse and consisted of a moderate number of individuals (mean = 16/plot). The conifer forest was the most extensive habitat and was composed of a mixed softwood/ hardwood (56/44%) forest with high overstorey cover (66%), high understorey cover (66%), low herb cover (33%), and high litter cover (64%). The conifer forest supported the highest soil invertebrate diversity although few RTU (low RTU richness) and few individuals (mean = 10/plot; Table 2). The conifer-grass forest type was represented by a relatively low overstorey (55%), intermediate understorey (56%), high conifer cover (53%) with the most grass (13%) and more herb than litter cover (66/22%). The soil invertebrate community in the conifer-grass habitat was the least diverse with the lowest RTU richness and fewest individuals per plot ($n = 9$).

The abundance of three out of the six most numerous RTU were significantly related to forest characteristics

TABLE 2. Comparison of forest and soil invertebrate characteristics for five forest types. Mean invertebrate abundances (numbers per m^2) are given for six of the more common invertebrates. Means with the same letters do not differ significantly according to Tukey's multiple range test.

			Forest types				
Variable	F	P	Upland hardwood (n = 6)	Lowland hardwood (n = 2)	Shrub (n = 4)	Conifer (n = 6)	Conifer-grass (n = 2)
Forest characteristics							
Snags	6.0	0.005	ab 13.3	a 16.0	b 4.3	ab 7.5	b 5.5
Logs	10.5	0.0003	ab 7.0	a 15.0	c 2.3	bc 2.7	c 2.0
Soil moisture	26.7	0.0001	b 0.6	a 1.4	c 0.0	c 0.1	c 0.0
Overstorey	5.1	0.008	ab 52.8	a 69.5	b 34.3	a 65.7	ab 54.5
Understorey	4.4	0.01	b 46.5	ab 54.5	a 77.8	ab 66.3	ab 56.0
Herb	28.3	0.0001	a 89.5	ab 68.5	bc 56.8	c 32.8	b 65.5
Litter	26.0	0.0001	c 2.8	cb 14.0	b 31.8	a 64.2	cb 21.5
Grass	25.7	0.0001	b 1.7	b 0.5	b 3.5	b 1.2	a 13.0
Conifer	19.0	0.0001	b 21.8	b 26.0	ab 36.0	a 55.8	a 53.0
Indices of diversity							
Shannon's	5.64	0.006	a 2.15	ab 1.99	a 2.17	a 2.19	b 1.90
Simpson's	7.37	0.002	ab 0.191	b 0.155	b 0.147	b 0.142	a 0.228
RTU richness	5.73	0.005	a 19.3	ab 17.0	ab 16.3	ab 14.5	b 14.0
Number of individuals	9.11	0.0006	ab 475	a 723	bc 313	c 190	c 179
Soil invertebrates							
Springtails	3.64	0.03	ab 67.8	a 120.5	ab 65.0	b 46.2	ab 76.5
Beetles	0.6	0.70	16.5	10.0	11.3	16.5	4.5
Centipedes	1.2	0.34	7.5	10.5	12.0	6.5	20.0
Slugs	0.8	0.52	4.0	6.0	5.3	6.3	6.0
Earthworms	8.8	0.002	a 54.5	a 116.5	ab 32.3	b 21.0	b 14.0
Isopods	5.9	0.005	a 127.3	ab 96.5	ab 64.5	b 25.3	b 14.5

(Table 1). Springtail abundance increased with greater litter cover (22.4% of variation explained; F = 5.2, P = 0.04). Earthworm abundance was negatively correlated with percent conifer cover (65.7% explained variance) and positively correlated with number of logs (10%; F = 34.4, P < 0.001). Isopod abundance was negatively related to percent conifer cover (62.4% of variation explained; F = 29.9, P < 0.001; Table 1). In contrast, beetles, centipedes, and slugs were relatively evenly distributed across forest types and their abundance was not significantly related to forest characteristics (not shown in Table 1).

Discussion

Our findings are consistent with the view that diversity is greater in the most common habitat within a varied landscape, such as a mixed-wood boreal forest (<80 y) and is often characterised by intermediate productivity and disturbance. Simpson's and Shannon's Indices of Diversity explained similar amounts of variation in the pattern of diversity of soil invertebrates with forest characteristics. Both found percent herbaceous cover the most important environmental factor explaining the pattern of soil invertebrate diversity among forest habitats. Also, both indices showed similar correlations, in magnitude and direction, such that as diversity increased the percentage of herbaceous cover decreased. In contrast to our findings, soil invertebrates from 27 orders did not differ significantly among five different landscapes (with the exception of earthworms) (Kalisz and Powell 2000).

We found a negative relation of soil invertebrate diversity with increasing composition of conifer vegetation. Few herbs and more litter are present under the conifer cover due to greater soil acidity (Kimmins 1997). Numbers of invertebrates were greater under herbaceous cover but diversity was reduced. Other studies have found invertebrates occurring in greater numbers under deciduous and herbaceous cover relative to conifer litter (Wallwork 1983; Paquin and Coderre 1997; Hammond 1997; Marra and Edmonds 1998). Within varied forest landscapes, the greatest diversity of soil invertebrates likely occurs for the most common (in time and space) successional community. In northern boreal forests this is likely for older conifer stands with greater overstorey and reduced ground vegetation understorey. Removal of conifers by natural disturbance or forest harvesting likely results in lower initial diversity with increasing diversity over time as other plants colonize the habitat (i.e., succession). We found greater invertebrate density under herbaceous cover associated with hardwood forest, but diversity

was lower relative to the conifer forest. More research is required to explain these differences.

There are some limitations to the sampling methodology used in this study. Taxonomic levels lower than the one used here to identify invertebrates would certainly provide more detailed results though sampling efficiency would be reduced. Sampling was done around mid-day, which limits sampling to invertebrate groups that are active during the day (Eisenbeis and Wichard 1987). Results are limited to the invertebrates visually observed (i.e., >1 mm which may exclude arthropods such as small mites) found under boxes whereas smaller individuals and groups found in deeper soil are under-represented. Another potential concern is that ants, due to their clumped distribution and significant effects on community structure, may obscure patterns among other invertebrate groups (Madden and Fox 1997).

Diversity indices respond to both changes in species richness estimates and changes in species evenness. For example, the mesic lowland hardwood site recorded few RTU but high total density. Among those common taxa associated with the mesic lowland sites are springtails, earthworms, and isopods, which might be expected to be more abundant in moist soils. As a result, one problem with interpretation of diversity results is the possible relationship between measures of richness and diversity relative to measures of density. Both Shannon's and Simpson's indices are expected to be lowest when richness and evenness are low and to increase with richness and evenness. Shannon's index is more sensitive to richness and is impacted by the inclusion of rare taxa, while Simpson's index is more sensitive to evenness of the more common taxa. The result is usually that the two are generally correlated, although the relative ranking of sites may differ somewhat. Among the five forest types reported in Table 2, the two hardwood sites had the highest numbers of individuals. Both Shannon's and Simpson's indices are reported as moderate for these sites with higher estimates for both in the upland sites. The two conifer-grass sites yielded the lowest number of individuals. The Shannon's estimate is the lowest of the five sites while the Simpson's is the highest. Between the other two sites, which recorded somewhat higher numbers of individuals, the Shannon's estimates are the two highest while the Simpson's estimates are the two lowest. The net effect is that across all five habitat types the correlation coefficient between the Shannon and Simpson estimates for the forest stands arranged along a moisture gradient had a negative slope, although not significant, contrary to expectations. However, both indices were negatively correlated with % herb cover and positively correlated with each other. Greater replicates are required in various forest stands along environmental gradients to account for forest characteristics that covary.

Although increasing plant diversity significantly increases invertebrate diversity, local herbivore diversity is also maintained by a diversity of parasites (e.g., flies and nematodes) and predators (Siemann et al. 1998; Ferguson 2001). A community-level prediction is that invertebrate diversity increases with increasing plant species diversity, as many invertebrates forage on the leaves and litter of herbaceous plants (Symstad et al. 2000). However, if an entire functional group of plants, such as conifers, is absent from a habitat, then a landscape-level decrease in soil invertebrate diversity would occur, as many taxa are associated with the acidic soil and fungal hyphae characteristic of coniferous forest floors (Lattin 1993; Butterfield 1999). Alternatively, diversity is hypothesized to increase and decrease across the two dimensions of productivity and disturbance, respectively (Kondoh 2001). Our results conform to this view, as conifer cover had the highest diversity at the late successional stage but the lowest measure of diversity at the early conifer-grass stage. In contrast, more constant mesic hardwood habitats had high productivity and low disturbance, and showed intermediate indices of invertebrate diversity. Apparently, the pattern of invertebrate community diversity varied among habitat types according to productivity and disturbance gradients.

The decrease in soil invertebrate diversity with increasing grass cover may be due to the low nutritive value of grass and the microhabitat conditions of grassy areas. Low moisture, associated with dry grassy areas, has been found to have an adverse effect on soil invertebrate abundance due to a reduced oxygen level that degrades soil composition, increases erosion, and mobilizes carbohydrates and nutrients (Marra and Edmonds 1998). The majority of soil invertebrates are best suited to moderate moisture levels, as some species have little or no exoskeleton (e.g., earthworms) to protect against high and low soil moisture (Schaefer 1995; Ferguson 2004).

Soil invertebrate diversity was not significantly related to many of the forest characteristics. Still, the considerable diversity of invertebrates ensures that some species are adapted to many of the diverse conditions. For example, soil invertebrates did not show a relationship to the number of downed logs. This lack of a relationship with logs may have been related to the experimental technique of providing a similar microhabitat using boxes. Many soil invertebrates are known to depend on cover provided by coarse woody debris, such as downed logs, due to their provision of nutrients and protection from predators and stability of microclimatic conditions (Lattin 1993; Ferguson and Joly 2002). Slugs showed few relationships with forest characteristics and were found in a diversity of habitats. Slugs forage on larvae of beetles and flies and on cellulose and other plant polysaccharides (Port and Port 1986). Earthworms burrow in moist rich soil and feed on decaying organic matter from fallen leaves and vegetation (Edwards and Bohlen 1996). Earthworms were found to be positively associated with herbaceous cover, nega-

tively associated with conifer cover, and positively associated with soil moisture. The major food items of centipedes are earthworms and small arthropods (Formanowicz and Bradley 1987). Although centipedes have been found to prefer moist habitats (Corey and Stout 1992), such as under logs, no significant relationships were found with the forest characteristics measured in this study.

Springtails are abundant in soil, and consume decomposing plant material and fungal hyphae (Hopkin 1997). Their abundance was negatively associated with litter cover, perhaps because it is living annual plants that provide the overwinter dead material that fungal hyphae provide as springtail food. The non-significant correlation ($P = 0.06$) of springtail abundance with herbaceous cover and the negative association with conifer composition contradicts other studies (Butterfield 1999; Paquin and Coderre 1997). A possible explanation for these differences is the differing sampling methodologies used whereby surface-dwelling springtails were sampled here, in contrast to sub-surface sampling from other studies.

Beetles showed little dependence on any of the measured forest characteristics in this study, in contrast to another study that found habitat dependencies (Fournier and Loreau 2001). Beetles are adapted to a wide range of environments partly due to their exoskeleton enabling life in a variety of moisture conditions (Eisenbeis and Wichard 1987). Isopods occur in greater abundance under stones and in damp environments (Sutton 1980), which is confirmed in this study by the positive association with relative soil moisture. Also, isopods were positively associated with herbaceous versus conifer cover, which is related to intolerance to acidic conditions of conifer soils and the greater food availability in deciduous and herbaceous forest cover (David et al. 2001). These findings differ with previous research that found isopod abundance unrelated to forest attributes (Bolger et al. 2000).

Forest management, with the goal of preserving forest biodiversity that includes soil invertebrates, needs to consider the requirements of individual taxa in boreal ecosystems by providing varied landscapes within a mosaic of forest stands. For example, climate change may profoundly influence boreal forest ecosystems and their management, via increased temperature and altered precipitation regimes (e.g., fires, etc.; Parker et al. 2000). In the boreal forest area studied here, conifer habitat had the highest diversity, although abundance and RTU richness were lower. However, our results need to be guardedly interpreted as they are based upon observations of a partly artificial system and our invertebrate diversity results are not sufficiently comprehensive to draw management conclusions. Still, monitoring soil invertebrate diversity can provide a means to assess changes in forest environments with climate warming as well as forest management practices that include silvicultural interventions to maintain forest health.

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Observations of Habitat Use by Polar Bears, *Ursus maritimus*, in the Alaskan Beaufort, Chukchi, and Northern Bering Seas

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Hansen, Donald J. 2004. Observations of habitat use by Polar Bears, *Ursus maritimus*, in the Alaskan Beaufort, Chukchi, and northern Bering Seas. Canadian Field-Naturalist 118(3): 395-399.

A total of 1 112 Polar Bears (*Ursus maritimus*) at 482 sightings were recorded during aerial surveys in the Beaufort, Chukchi, and northern Bering Seas conducted primarily during September and October from 1979-1999. Of these bears, 784 were observed offshore at 400 sightings. The surveys were conducted by the Naval Ocean Systems Center and Minerals Management Service; they were designed to monitor the fall Bowhead Whale (*Balaena mysticetus)* migration. Over the 20-year period, 1 096 620 kilometers of surveys were flown. The majority of the offshore Polar Bears, 595 bears at 290 sightings, and most of the kill sites and polar bear tracks were recorded in 80-100% ice cover. The number of bears per kilometer increased substantially in >24% ice cover, with the highest number observed in 80-100% ice cover. This habitat use probably is related to the availability of seals, their primary prey. There were 328 bears (83 sightings) recorded on land, and most of them were associated with whale carcasses and bowhead whale subsistence harvest sites along the Alaskan Beaufort Sea coast.

Key Words: Polar Bear, *Ursus maritimus*, habitat, Beaufort Sea, Chukchi Sea, Northern Bering Sea, Alaska.

The preference of Polar Bears for extensive ice habitats is well documented (Stirling et al. 1993; Stirling and Derocher 1993; Amstrup 1995). Polar Bears need an ice platform to hunt successfully for seals, their primary prey (Stirling, Andriashek, and Calvert 1993). The bears select ice habitats that increase accessibility (availability) of seals. Ferguson et al. (2000) compared ice-habitat use by Polar Bears of the Canadian Arctic Archipelago and Baffin Bay. They found ice-habitat use to be similar for the two regions. However, Baffin Bay bears had more limited access to Ringed Seals (*Phoca hispida)* because of the complete absence of ice cover during the summer season. The Canadian Arctic Archipelago had more consistent seasonal ice cover, which provided the bears with reliable access to the seals. Although the Baffin Bay region had a much higher density of Ringed Seals (1.4-2.1 seals/square kilometer: Finley et al. 1983; Stirling and Oritsland 1995) than the Arctic Archipelago region (0.28-0.97seals/square kilometer: Kingsley, Stirling, and Calvert 1985), both regions had very similar Polar Bear densities. Ferguson et al. (2000) concluded that Polar Bear abundance is not always proportional to prey density because of differences in Polar Bear access to seals (i.e., availability of prey).

During September and October (open-water season), the Alaskan Beaufort Sea has great variability in ice coverage from year to year (Figures 1a and 1b). Like Baffin Bay, the Arctic coast of Alaska during light ice years is free of ice during the open-water season, when the pack ice is more than 100 miles from the coast (see Figure 1a). During the absence of ice in coastal Beaufort Sea habitats, bears that occur along the coast either scavenge on animal carcasses that wash ashore, feed on the remains of whale carcasses at subsistence whale harvest sites, or fast until shorefast ice forms and seals become available (United States Department of the Interior, Fish and Wildlife Service 1995).

During heavy ice years, the pack ice remains on the continental shelf; ice floes are common in coastal waters, and shorefast ice remains or forms early during the fall (Figure 1b). These varying ice conditions affected the movements and distribution of Polar Bears in the Beaufort and Chukchi seas (Amstrup 2000).

Methods and Materials

From 1979-1999, the Naval Ocean Systems Center under contract with the Bureau of Land Management (1979-1982) and Minerals Management Service (1982-1999) under the Bowhead Whale Aerial Survey Project has conducted aerial surveys in the Beaufort, Chukchi, and Bering seas (Ljungblad et al. 1986; Moore and Clarke 1992; Treacy 2000) to monitor the fall migration (late August through October) of endangered whales (Treacy 2000). Information on Polar Bears and sea-ice coverage was acquired mostly from these aerial surveys. Surveys were flown primarily at 1500 feet (458 meters), weather permitting, or at a minimum of 1000 feet (305 meters) to avoid disturbing marine mammals. The aircraft used was a de Havilland Twin Otter Series 300 with bubble windows on both sides of the plane. Earlier flights (1979-1991) over the northern Bering, Chukchi, and western Beaufort seas used a Grumman Turbo Goose model G21G (Ljungblad et al. 1986; Moore and Clarke 1992).

Information also was used from aerial whale surveys conducted during the spring and summer (April through August) in the northern Bering Sea as well

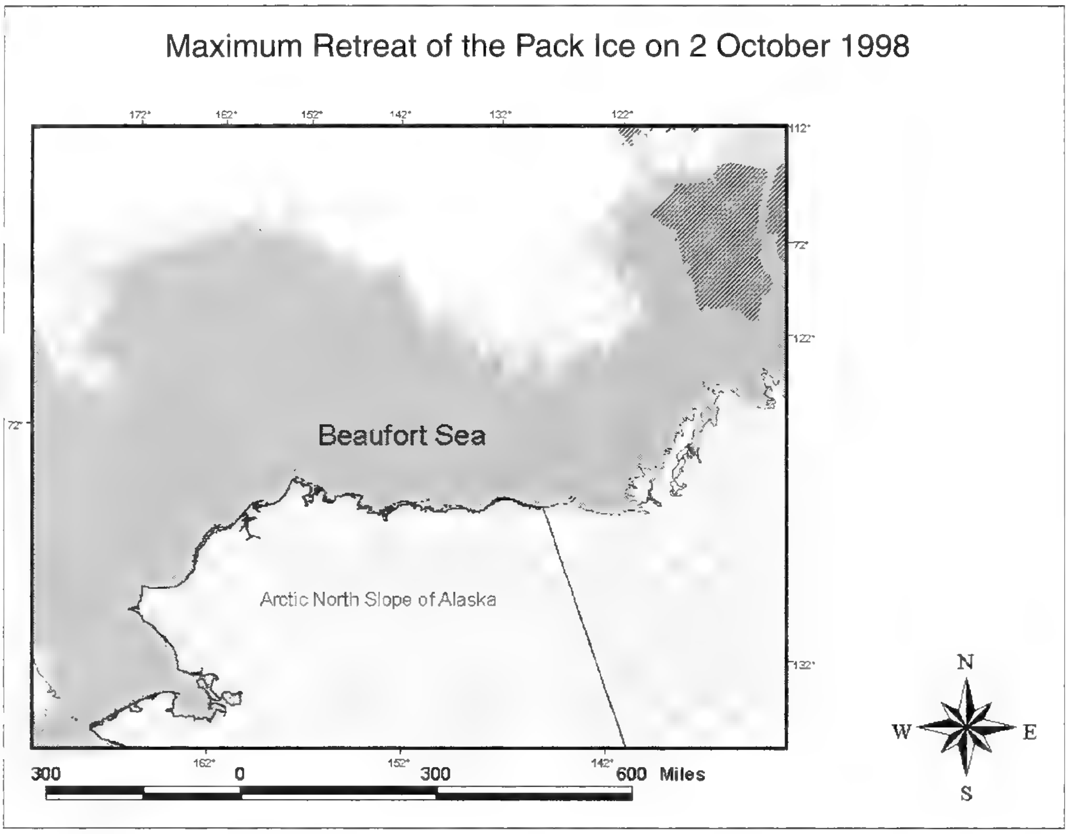

FIGURE 1a. Light Ice Year Information derived from the National Naval Ice Center (http://www.natice.noaa.gov/westarct1.htm).

Maximum Retreat of the Pack Ice on 18 September 1983

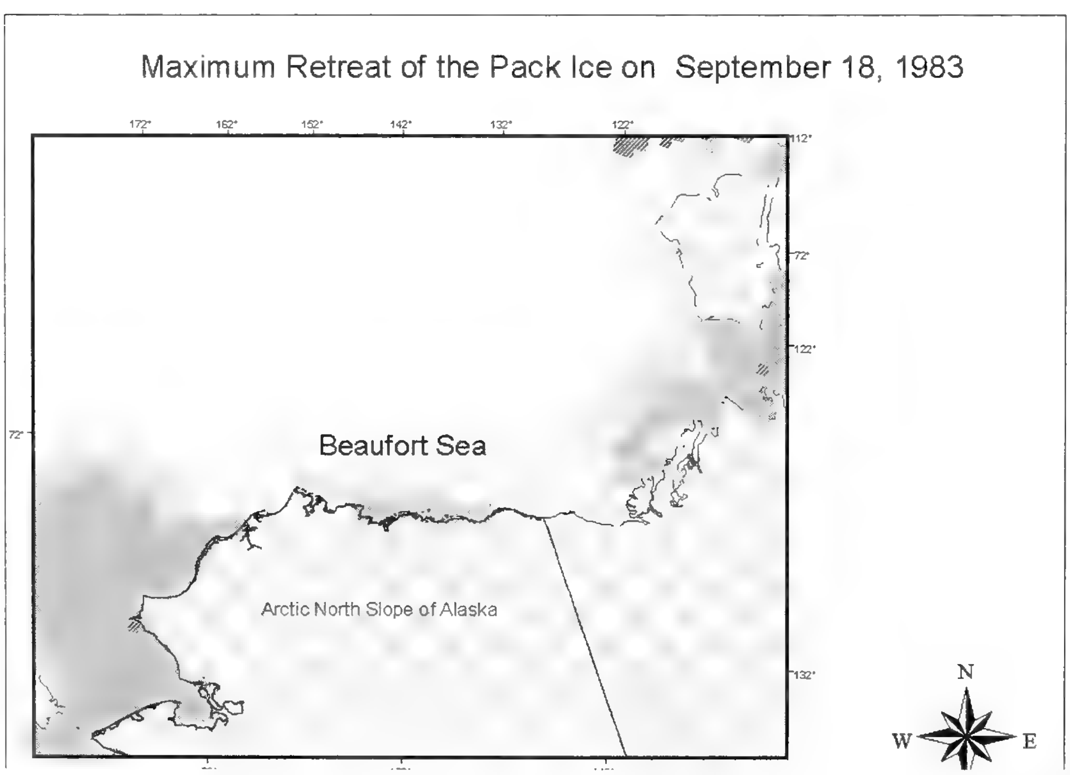

FIGURE 1b. Heavy Ice Year information derived from the National Naval Ice Center (http://www.natice.noaa.gov/westarct1.htm).

as in the Chukchi and Beaufort seas (Ljungblad et al. 1986; Moore and Clarke 1992). Incidental sightings of Polar Bears and their behavior were recorded along north-south transects and off transects along the remainder of the flight tracks (Figure 2). Information was recorded on percent ice coverage within about 1-2 kilometers of the aircraft at each position update (once about every 5 minutes) and at each sighting loca-

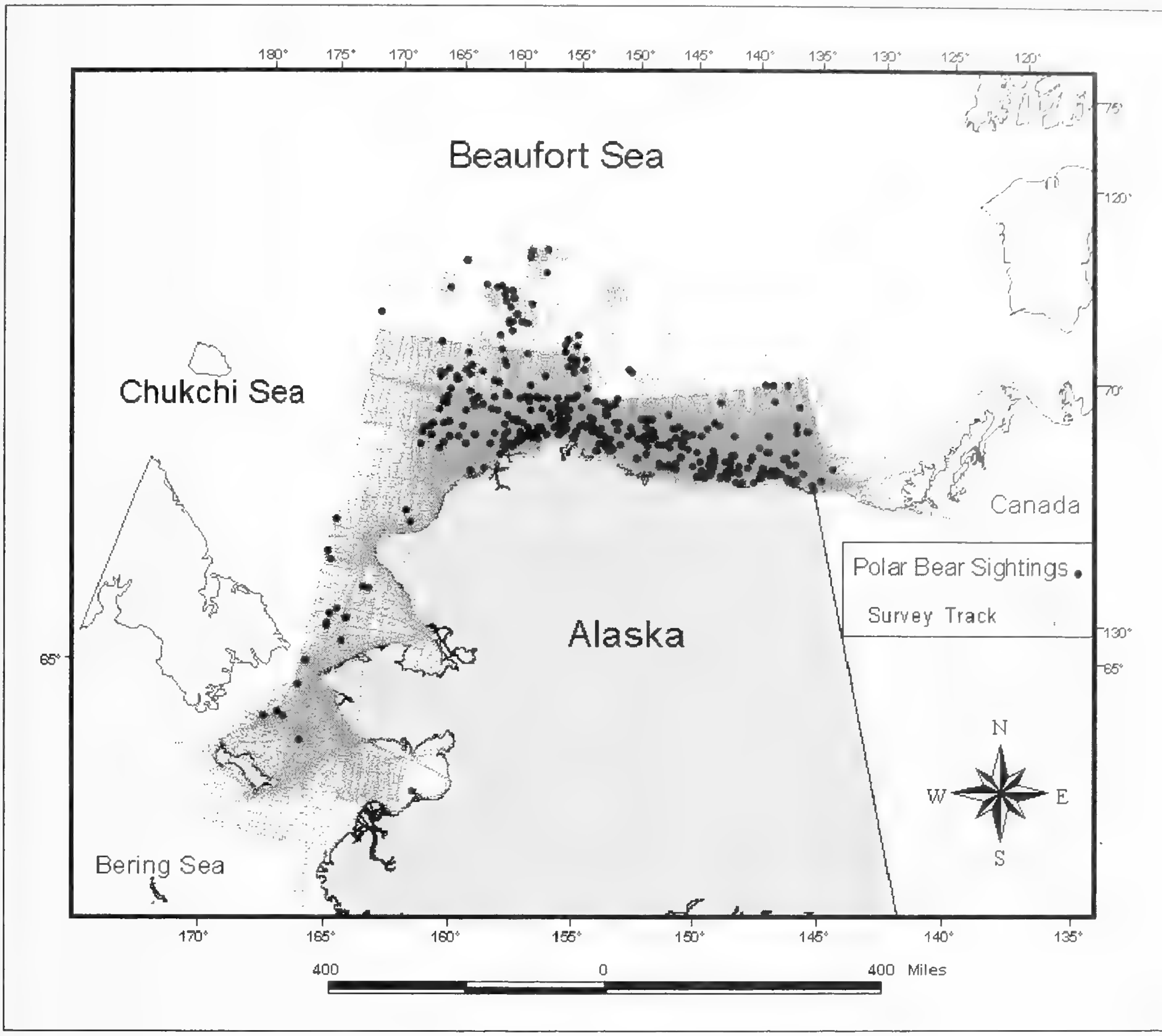

FIGURE 2. Study are with survey tracks and Polar Bear sightings.

tion. Position updates, sighting locations, and ice-coverage data were recorded on an onboard computer system connected to a Global Positioning System receiver in the aircraft. These records included information on numbers of Polar Bears per sighting and ice cover within about 1-2 kilometers of the aircraft. Polar Bear tracks and kill sites also were recorded during September and October from 1987 through 1999.

Survey effort in the Beaufort Sea focused primarily along the coast, continental shelf, and shelf break, while surveys in the northern Bering and eastern Chukchi seas extended from the coast to the International Date Line (Figure 2). The Polar Bear sightings, kill sites, locations of bear tracks, and ice-coverage data were converted into database files and analyzed with Arcview Geographic Information System Program 3.2a (developed by ESRI in Redland, Calif.). Tables and graphs were created in Microsoft Word and Microsoft Excel (Windows 2000) to compare bear numbers and sightings with ice coverage (Table 1 and Figure 3) and kill sites and bear tracks with ice cover (Figures 4 and 5). The number of bear sightings and the survey effort (kilometers flown) were plotted by ice category to compare ice-cover use (Figure 2). This analysis is providing useful information on habitat use by Polar Bears occurring in Alaskan waters.

Results and Discussion

Table 1 shows the number of Polar Bears and number of sightings recorded offshore by ice cover and on the mainland or on barrier islands. Figure 4 shows the number of Polar Bear kill sites and ice coverage recorded at the kill locations. Figure 5 shows the numbers of Polar Bear tracks recorded and ice coverage at their locations.

Over the 20-year period and the 1 096 620 kilometers of surveys flown, 1112 Polar Bears at 482 sightings were recorded in the Beaufort, Chukchi, and Bering

TABLE 1. Number of Polar Bears and Number of Sightings (Recorded Per Year) by Ice Coverage and Number Recorded on Land.

Year	80-100% Ice Ice	50-79% Ice	25-49% Ice	1-24% Ice	No Ice	On Land	Total Number of Bears and Sightings
1979	15 (8)				5 (2)		20 (10)
1980	29 (21)	1 (1)	13 (5)	4 (2)			47 (29)
1981	50 (15)	3 (2)	12 (1)	4 (2)			69 (20)
1982	16 (13)	4 (4)	1 (1)		1 (1)		22 (19)
1983	76 (35)	14 (11)	3 (3)				93 (49)
1984	23 (15)	5 (2)	3 (2)	3 (2)	1 (1)		35 (22)
1985	5 (3)	1 (1)					6 (4)
1986	9 (6)	3 (2)		3 (2)			15 (10)
1987	4 (2)	1 (1)					5 (3)
1988	69 (43)	1 (1)	2 (2)				72 (46)
1989	15 (10)	11 (7)	6 (5)	5 (3)			37 (25)
1990	52 (40)	1 (1)					53 (41)
1991	22 (13)	4 (2)	1 (1)	1 (1)	1 (1)		29 (18)
1992	105 (31)	31 (12)				67 (5)	203 (48)
1993			3 (1)	2 (2)			5 (3)
1994	26 (12)	2 (1)	3 (2)	1 (1)			32 (16)
1995			2 (1)	3 (1)			5 (2)
1996	9 (7)		1 (1)				10 (8)
1997	53 (8)		1 (1)			11 (2)	65 (11)
1998	15 (6)	9 (4)	1 (1)		8 (5)	217 (57)	247 (73)
1999	2 (2)		1 (1)		3 (3)	33 (19)	39 (25)
Totals:	595 (290)	91 (52)	45 (23)	28 (17)	25 (17)	328 (83)	1112 (482)

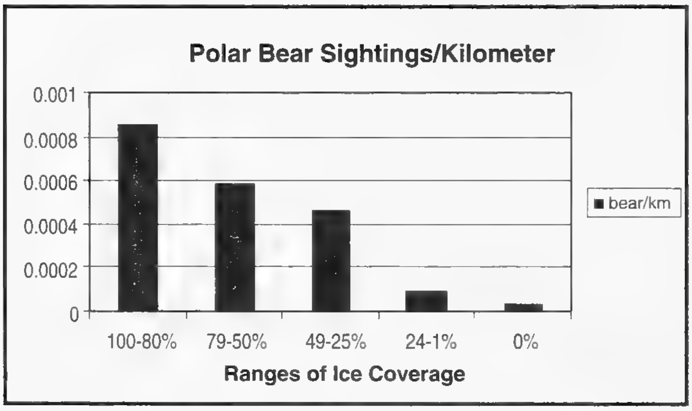

FIGURE 3. Polar Bear sightings per kilometer recorded from April 1979 through October 1999 in the Beaufort, Chukchi and Bering Seas.

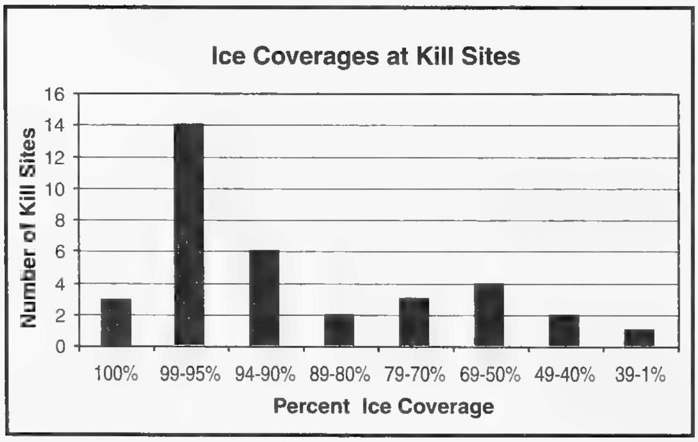

FIGURE 4. Number of kill sites and ice coveage recorded at each site.

seas from 1979-1999 (Table 1). Of these bears, 784 were observed offshore at 400 sightings. Figure 2 shows the number of Polar Bears per kilometer of survey effort over ranges of ice coverage. The number of bears per kilometer increased substantially in >24% ice cover, with the highest number observed in 80-100% ice cover. These observations suggest that Polar Bears may use 80-100% ice cover more often than lower percentages of ice cover. This habitat use probably is related to the availability of seals, their primary prey. Table 1 lists the number of bears and sightings seen offshore in other ice concentrations. Thirty-five kill sites and 769 Polar Bear track sightings were recorded, mostly in 80-100% ice cover (Figures 3 and 4, respectively). Tracks with zero ice cover were recorded on land or barrier islands.

A total of 328 bears (at 83 sightings) were recorded on the mainland or on barrier islands (Table 1). Most of these bears were associated with whale carcasses and bowhead whale subsistence harvest sites along the Beaufort Sea coast. The large numbers of bears were recorded on land in 1992 (67 bears) and 1998 (217 bears), when repeat sightings were made of several bears feeding on whale carcasses along the Beaufort Sea coast (Table 1).

Studies of radio- and satellite-tagged Polar Bears have provided useful information on the movements and habitat use of individual Polar Bears (Arthur et al. 1996; Ferguson et al. 1998; Amstrup et al. 2001; Durner et al. 2004). These studies recorded Polar Bear locations and compared them with satellite-derived,

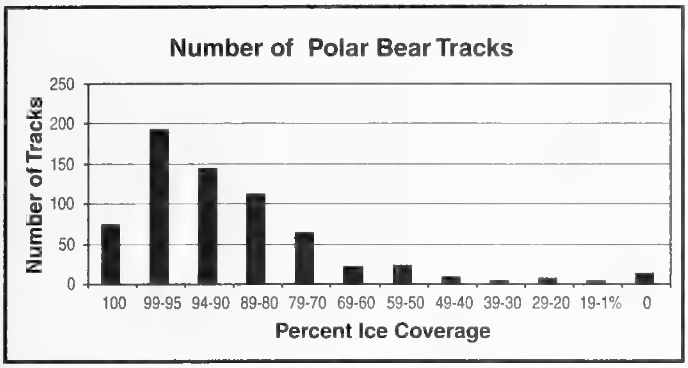

FIGURE 5. Number of Polar Bear tracks and ice coverage recorded at each site.

digitized maps of ice types and ice concentrations in the general areas where the bears were located. These remote-sensing techniques provide general information on habitat use by Polar Bears throughout the year. Aerial surveys in this study recorded ice types and ice concentrations within 1-2 kilometers of the aircraft along the flight track and at the specific locations where Polar Bears were observed. Both techniques record information on habitat use. Aerial surveys provide real-time information on habitat use at the actual locations where the bears were observed, while remote-sensing techniques provide valuable information on bear movements and general information on habitat use over time.

Many aerial surveys conducted specifically for Polar Bears are flown at lower altitudes than the 1500 foot surveys conducted in this study. Aerial surveys that are conducted at very low altitudes (200-300 feet) are very likely to disturb Polar Bears and other wildlife. Our surveys were conducted at 1500 feet to avoid disturbing marine mammals. Even at 1500 feet some of the bears observed reacted to the aircraft by running away when the aircraft past overhead. Polar Bears are quite visible on the ice at 1500 feet because their tracks are very detectable. Other marine mammals of comparable size to Polar Bears, such as Beluga Whales, are easily detected at 1500 feet.

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New Records for the Arctic Shrew, *Sorex arcticus* and the Newly Recognized Maritime Shrew, *Sorex maritimensis*

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Perry, Neil D., Donald T. Stewart, Elizabeth M. Madden, and Thomas J. Maier. 2004. New records for the Arctic Shrew, *Sorex arcticus*, and the newly recognized Maritime Shrew, *Sorex maritimensis*. Canadian Field-Naturalist 118(3): 400-404.

We report the first record for the Arctic Shrew (*Sorex arcticus*) in the state of Montana, USA. We also report range extensions for the closely related Maritime Shrew (*Sorex maritimensis*) in New Brunswick and Nova Scotia, Canada. These collections augment our limited knowledge of the ranges and habitat associations of these rarely collected shrews, and highlight the need for a careful assessment of the status of *S. maritimensis* in Canada.

Key Words: Arctic Shrew, *Sorex arcticus*, Maritime Shrew, *Sorex maritimensis*, range, state record, Montana, New Brunswick, Nova Scotia, Quebec.

Approximately 38 species of shrews (genus *Sorex*) are currently recognized in North America (Hall 1981; Jones et al. 1986; George 1988; Wolsan and Hutterer 1998; Fumagalli et al. 1999). Most North American shrews belong to the subgenus *Otisorex*, which is primarily restricted to this continent. Until recently, the only two recognized members of the subgenus *Sorex* found in North America were the Tundra Shrew (*Sorex tundrensis*) and the Arctic Shrew (*Sorex arcticus*) (van Zyll de Jong 1983a), the latter species documented throughout much of the boreal forest region of North America. Recent molecular work, however, has supported the recognition of the Maritime Shrew (*Sorex maritimensis*, previously *S. arcticus maritimensis*) as a distinct species (Stewart et al. 2002). The range of the Maritime Shrew is limited to the eastern portion of New Brunswick and Nova Scotia.

Sorex arcticus and *S. maritimensis* are infrequently observed or collected. Both species exhibit a preference for grass-sedge meadows and wetland edges (Wrigley et al. 1979; van Zyll de Jong 1983b; Kirkland and Schmidt 1996). Although there are limited studies which include estimates of density (Buckner 1966), both species appear to exist at lower population densities than other common mammal species of the boreal region (e.g., Masked Shrew [*Sorex cinereus*] and Meadow Vole [*Microtus pennsylvanicus*]), although they may be locally common in appropriate habitat (Wrigley et al. 1979). *Sorex maritimensis*, because of its limited range and restriction to areas of grass-sedges, is considered rare (van Zyll de Jong 1983b). This may be a result of competitive exclusion by similar sized Smoky Shrews (*Sorex fumeus*) which exhibit a preference for less mesic, wooded habitats (van Zyll de Jong 1983a).

Herein we report the first record of *S. arcticus* in Montana and range extensions of *S. maritimensis* in New Brunswick and Nova Scotia, and provide additional data on habitat associations in these locations. We also report a collection of *S. arcticus* in Sept Iles, Quebec, one of only six records within the province (Peterson 1966; van Zyll de Jong 1983b). In the following sections, we detail trapping methods and results for each collection.

Methods

Montana, USA. Between 22 and 27 July 2001 we conducted small mammal baseline surveys on wet meadow habitats at Medicine Lake National Wildlife Refuge, Sheridan County, northeast Montana (48°30'N, 104°20'W; Figure 1). The refuge is located in the glacially influenced prairie pothole region, noted for its gentle rolling plains with occasional shallow depressions—host to vast wetlands and seasonally flooded meadows.

We set two 150 m transects, each with 10 trap stations set 15 m apart for five consecutive nights. Each station included three different Victor® snap-traps: one mouse trap, one museum special trap, and one rat trap (300 trap nights). Nearby pitfall traps consisted of two 5-m fences (aluminum flashing) with 5-L paint buckets (dry, not baited) at either end (40 trap nights; each night a bucket was open was considered a trap night). The transects were located in the Lake Creek flood plain, an area seasonally inundated with water during spring run-off and early summer rains (Stuart and Kantrud 1971). The plant community was herbaceous, dominated by sedges (*Carex* spp.), grasses (*Agropyron* spp. and *Spartina* spp.), and rushes (*Juncus*

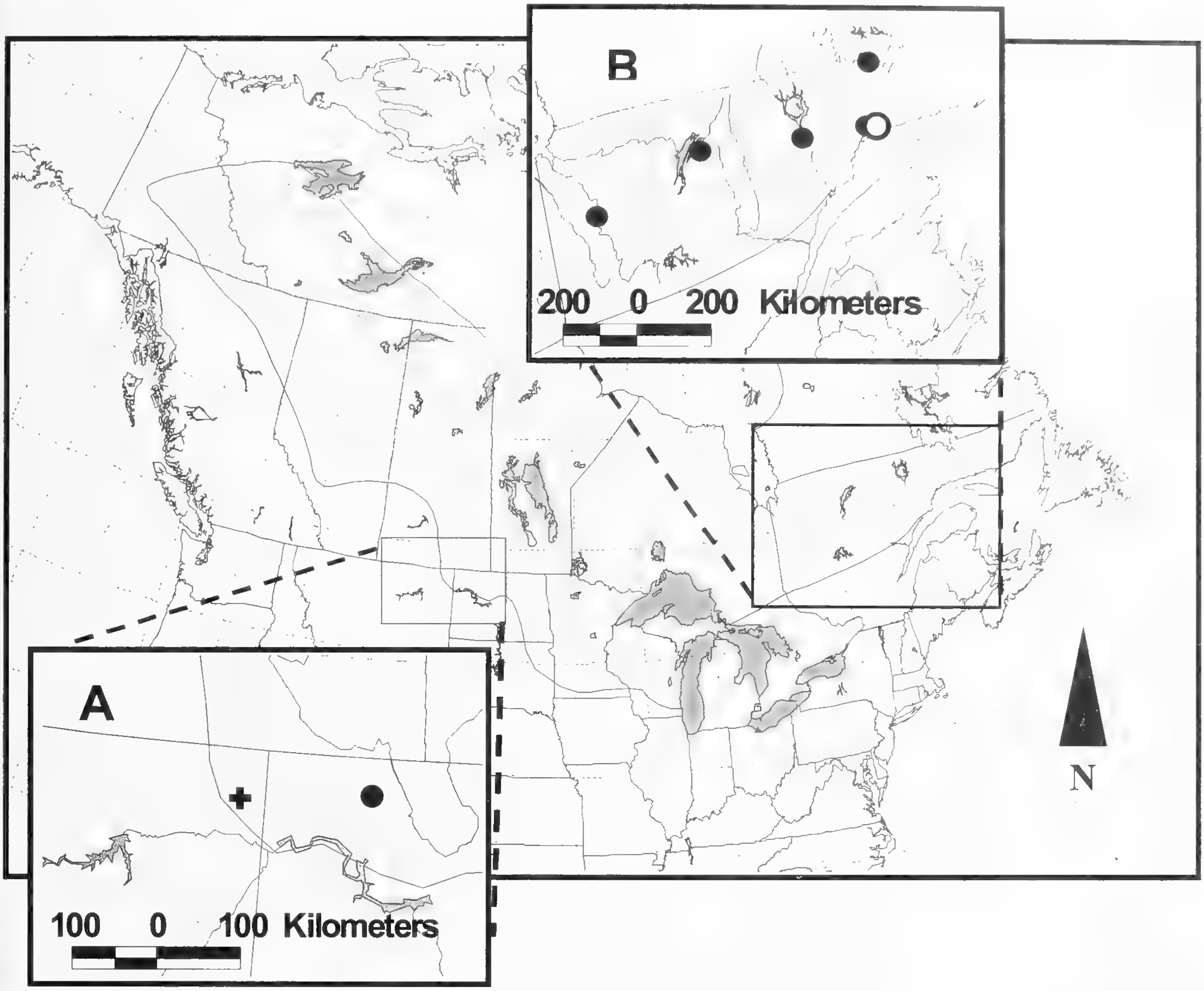

FIGURE 1. Suggested range for *Sorex arcticus*. Includes extensions presented herein and ranges suggested by Peterson (1966) and van Zyll de Jong (1983b). **Insets: A** + Indicates location of Montana *S. arcticus* collections, Medicine Lake National Wildlife Refuge. ● Indicates location of nearest known record, Lostwood National Wildlife Refuge, North Dakota. **B.** ○ Indicates the location of the Quebec *S. arcticus* collection, other points (●) indicate location of historical collections in Quebec.

spp.), with a variety of wetland forbs interspersed. Identical survey efforts were conducted in two additional habitat types on the refuge: native prairie and planted perennial grasslands. Total combined effort for all three habitat types was 900 snap trap nights and 120 pitfall nights.

Quebec, Canada. One hundred pitfall traps (800 trap nights) were set at each of two sites, 17-21 July 1990 (Figure 1). Sites were 8 km north and 8 km east of Sêpt Iles, Quebec (50°12'N, 66°23'W) in coniferous woodland near the edge of a marsh and in an old grassy field next to a road, respectively. The coniferous woodland/marsh was characterized by White Spruce (*Picea glauca*), Balsam Fir (*Abies balsamea*) and sedges (*Carex* spp.).

New Brunswick, Canada. A total of 175 non-baited pitfall traps (525 trap nights) were set 3 km southeast of St. George, near L'Etete, New Brunswick (45°8'N, 66°50'W), 3-7 August 1990 (Figure 2). Traps were set in thickets of predominantly alder (*Alnus* sp.) with some mixed conifer growth and some grasses. A small brook (0.5 m wide) transected the site, maintaining relatively moist soils.

Nova Scotia, Canada. [Method information is not available]

Results

Montana, USA. Six *S. arcticus,* the first confirmation of this species in Montana (Foresman 2001), were collected in wet meadows at Medicine Lake National Wildlife Refuge (Figure 1). The nearest known previous collection was at Lostwood National Wildlife Refuge, Burke and Mountrail counties, North Dakota, approximately 190 km to the east (R. Murphy, personal communication).

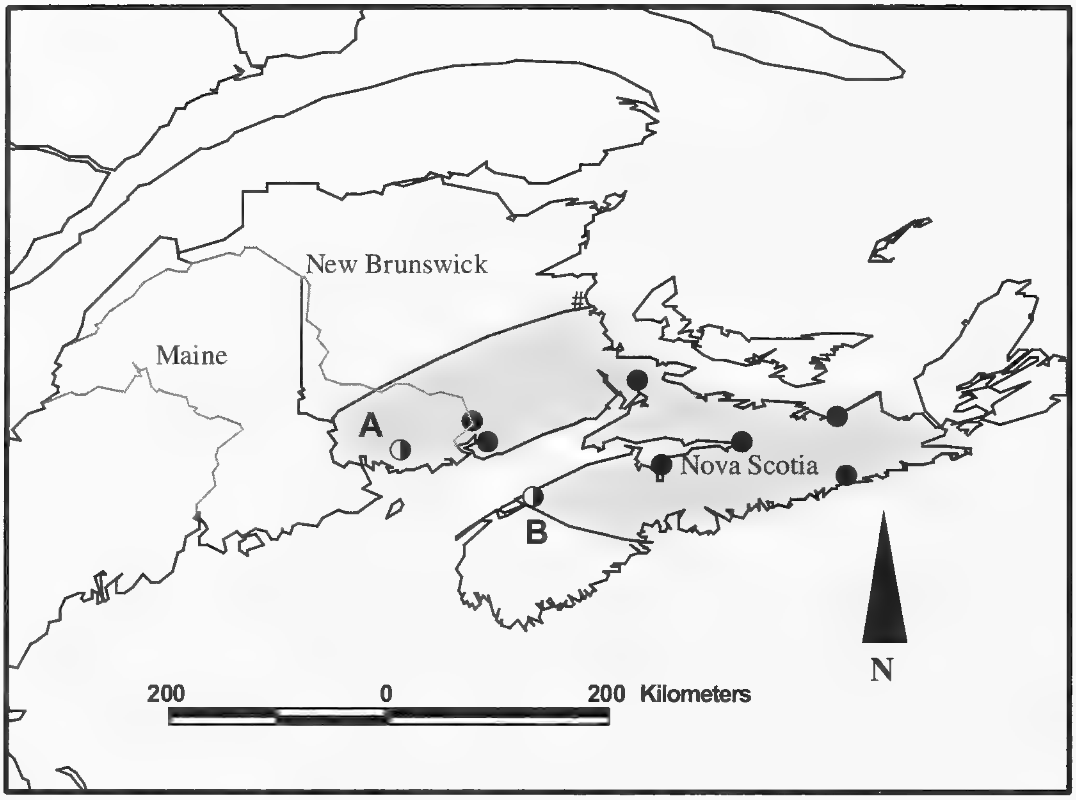

FIGURE 2. Suggested range of *Sorex maritimensis*, including collections described herein. **A** indicates the location of the St. George collection, New Brunswick. **B** indicates location of the Belle Isle collection, Nova Scotia. Historic locations, indicated by solid dots, were taken from van Zyll de Jong (1983b). We found no extralimital collections since that publication.

These specimens were captured using Victor® Museum Specials (n = 5) and Victor® rat traps (n = 1) baited with a mixture of peanut butter, oatmeal, flour, and black sunflower seeds. No *S. arcticus* were collected in either pitfall traps or smaller Victor® mousetraps. Although identical survey efforts were conducted in native prairie and planted perennial grasslands, *S. arcticus* were collected only in wet meadow habitats. Other species collected from wet meadow sites included: Meadow Vole (n = 19), Deer Mouse (*Peromyscus maniculatus*, n = 1), and Masked Shrew (n = 8).

All specimens were confirmed as *S. arcticus*; however, they were collected on the periphery of the *S. a. arcticus* and *S. a. laricorum* ranges, and identification to subspecies is difficult. These specimens are catalogued at the Philip L. Wright Zoological Museum at the University of Montana, Missoula (catalog numbers UMZM 18554 – 18559).

Quebec, Canada. Two Arctic Shrews (*S. a. arcticus*; Royal Ontario Museum [ROM] catalogue numbers 110254 and 110255) were collected by D.T.S. near Sept Iles, Quebec (50°12'N, 66°23'W), 17-21 July 1990 (Figure 1). This is the sixth reported collection of *S. arcticus* in this province (Peterson 1966; van Zyll de Jong 1983b). Both specimens were collected from the grassy site east of Sept Iles. Other species collected during this effort were Masked Shrew (n = 7), Pygmy Shrew (*Sorex hoyi*; n = 1), and Meadow Vole (n = 1).

This record is as far north along the immediate coast of the St. Lawrence River as *S. arcticus* have previously been reported. The last specimen in this general area, near Moisie River, just north of Sept Iles, was trapped in 1937 (van Zyll de Jong 1983b). Though little trapping has been conducted in this region, van Zyll de Jong (1983b) speculates that the species is distributed further north in Quebec and Labrador throughout the boreal forest, which includes extensive marshy habitats.

New Brunswick, Canada. Three Maritime Shrews (originally identified as *S. a. maritimensis*; ROM catalogue numbers 110314, 110315, 110331) were collected 3 km southeast of St. George, near L'Etete, New Brunswick (45°8'N, 66°50'W), 3-7 August 1990 (Figure 2). This collection extends the known range of *S. maritimensis* ca. 100 km south. Other species collected from this effort were Masked Shrew (n = 21) and Northern Short-tailed Shrew (*Blarina brevicauda*; n = 1).

Nova Scotia, Canada. On 4 October 1992, a single specimen of *Sorex maritimensis* (originally identified as *S. a. maritimensis*) was collected at Belle Isle, Nova Scotia (Tom Herman, personal communication). The specimen, collected in a marshy area dominated by the sedge *Scirpus cyperinus*, represents a provincial range extension of this species by ca.100 km (Figure 2).

Discussion

Sorex arcticus. The range of the Arctic Shrew is strongly associated with the boreal forest region of North America. Southward range expansions of four other boreal species, Masked Shrew, Meadow Vole, Meadow Jumping Mouse (*Zapus hudsonius*), and the Least Weasel (*Mustela nivalis*), have been correlated with contemporary cool, mesic climate patterns in the Great Plains region (Frey 1992). Jannett and Huber (1994) speculate that a recent southward extension of *S. arcticus* in Minnesota is associated with these cooling climate patterns. Indeed, this southwestward extension of *S. arcticus* into Montana could be correlated with this phenomenon.

Nevertheless, few small mammal surveys have been conducted in northeastern Montana (D. Flath, personal communication); it is possible this has prevented earlier detection in the state. Similar wet meadow habitat exists approximately 40 km to the south as the Big Muddy Creek feeds into the Missouri River. Thus, it is plausible that the range of *S. arcticus* extends further into Montana.

All Montana *S. arcticus* specimens were sexually inactive young-of-year. Clough (1963) observed that over-wintering *S. arcticus* captured between February and July were reproductively active. Also, the characteristic tri-colored pelage for adults of this species was indistinct in these specimens, further supporting our designation of these shrews as young-of-year, products of early season breeding by the previous year's cohort (Clough 1963; Baird et al. 1983). These specimens were collected in two groups of three, each group approximately 3 km apart and separated by a small perennial stream. Given their inactive reproductive status and that individuals from each group were collected no greater than 15 m apart, group members might have been litter-mates. As such, a viable population of *S. arcticus* likely exists at Medicine Lake National Wildlife Refuge.

Sorex maritimensis. The Maritime Shrew was previously considered restricted to the north and east of the St. John River system, with the nearest previous collection for this species near Saint John, New Brunswick (Peterson 1966; van Zyll de Jong 1983b). The collection of *S. maritimensis* near L'Etete, New Brunswick, brings this species within 30 km of the Maine border. Maine and New Brunswick are separated in this area by the St. Croix River which could be a barrier to shrew dispersal. There is suitable habitat for *S. maritimensis* on the U.S. side of the border and it is possible they will be found there; however, to date there is no record of *S. maritimensis* in Maine (J. Albright, R. Boone, and L. Master, personal communications). *S. maritimensis* is currently recognized as one of only four mammals endemic to Canada (the others are the Varying Lemmings [*Dicrostonyx hudsonius D. richardsoni*], the Gaspé Shrew [*Sorex gaspensis*], and the Vancouver Marmot [*Marmota vancouverensis*]).

The Nova Scotia and New Brunswick collections of the newly recognized *S. maritimensis* imply a greater range, extending inland and likely including the entirety of mainland Nova Scotia. Stewart et al. (2002) speculate that recent glacial encroachment (ca. 20 000 y) may have isolated this species on the coastal flood plain of Nova Scotia. These recent collections may either provide evidence that *S. maritimensis* is recolonizing former range, following the reestablishment of the boreal forest after the last ice age, or may reflect the paucity of efforts to collect *S. maritimensis* within suitable habitats in these provinces. These collections also support a hypothesis that this species is limited to moist grasslands and bogs associated with the boreal forest, competitively excluded from habitats occupied by the Smokey Shrew, a closely related woodland associate. This limited distribution and restriction to fragile wet meadow habitats suggests this species may warrant conservation concern.

These collections offer some data regarding the range and niche characteristics of these shrews. Given that *S. arcticus* and *S. maritimensis* have been the focus of very few research efforts, more research targeting specific life history traits are necessary to better understand the habitat associations and range restrictions of these shrew species.

Acknowledgments

We particularly thank Tom Herman for providing data on his specimen of *S. maritimensis* collected in Nova Scotia and Kerry Foresman for facilitating the processing and accession of Montana specimens into the University of Montana mammal collection. We also thank the staff at Medicine Lake National Wildlife Refuge for funding and support of small mammal collections on the refuge. We thank D. Flath and R. Murphy for insight into the status of *S. arcticus* in Montana and North Dakota. DTS thanks S. Hindocha and H. Russell for assistance in the field; and J. Albright, R. Boone, and L. Master for comments on the status of *S. maritimensis* in Maine. The research program of DTS is supported by an NSERC Discovery grant.

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Lichen Zonation on Coastal Rocks in Gwaii Haanas National Park Reserve, Haida Gwaii (Queen Charlotte Islands), British Columbia

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The occurrence of 43 marine lichen species on intertidal rocky shores of southern Haida Gwaii (Queen Charlotte Islands), British Columbia is described and related particularly to elevation on the shore (duration of seawater immersion) and exposure to waves. In the area of Gwaii Haanas National Park Reserve and Haida Heritage Site on Moresby Island, rock-dwelling marine lichens are distributed in zones much as they are elsewhere in the world, although some species found abundantly only in Haida Gwaii give the local shores a unique appearance. In common with other areas, there is a conspicuous black band of *Verrucaria* species (in this case, nine species plus other black lichens) at the upper edge of the intertidal zone. A conspicuous white band of *Coccotrema maritimum* above the black band is a unique feature of this flora. The unusually large percentage of endemic, near-endemic or disjunct lichen species and their phytogeography suggest that at least the headland rocks along the west coast were refugia during the last glacial maximum. *Verrucaria striatula* and *V. sandstedei* are reported for the first time from British Columbia.

Key Words: Maritime lichens, zonation, Haida Gwaii, Pacific Northwest, British Columbia.

Lichens form a dominant, yet often overlooked, component of the maritime vegetation along rocky seashores. They create distinct bands along such shores from polar to tropical seas with maximum abundance, and the most studies, in north-temperate regions (Fletcher 1980; Little and Kitching 1996). The species responsible for these bands in the northeast Pacific (i.e., the Pacific Northwest of North America; see the cover photo, and Plate 64 in Brodo et. al. 2001: 77), however, have rarely been investigated.

The shoreline lichen vegetation of Gwaii Haanas National Park Reserve and Haida Heritage Site can be understood in the context of the total lichen flora of Haida Gwaii, British Columbia. Five field trips by the senior author to Haida Gwaii since 1967 have revealed a diverse lichen flora of about 580 species with more than 25 new to science (Brodo 1995). Many of the species are rare worldwide, and more than a dozen are endemic to Haida Gwaii or are known only from a few nearby localities in southeast Alaska and Vancouver Island. Further, many species are disjuncts, having their nearest additional locality thousands of kilometres distant, often in western Europe, Asia or the southern hemisphere (Brodo 1992).

With the establishment of Gwaii Haanas as a National Park Reserve, there is a need to develop a baseline inventory of lichen species for various uses, for example, to facilitate the conservation of lichen biodiversity (Hunter and Webb 2002), to track human and natural perturbations, to assist in nature interpretation, and to aid studies of shoreline ecology. Lichens are well-known indicators of environmental health in use world-wide (Nimis et al. 2002). Regionally, they have been used for air quality monitoring in the Tongass National Forest in southeast Alaska (Geiser et el. 1994*). In addition, lichen studies have been made to evaluate the effects of oil spills and post-spill cleaning on marine ecosystems (Lallemant and Van Haluwyn 1981; Fletcher and Crump 2002). A knowledge of maritime lichens is clearly relevant to the prospect of oil and gas development in the Hecate Strait separating Haida Gwaii from the British Columbia mainland (Anonymous 2002*).

It is important to know if the shoreline lichens of Haida Gwaii differ from those found elsewhere on the west coast of North America. The only other detailed study of Pacific Northwest marine lichen zonation was done by Ryan (1988a, 1988b) in Washington State, although some observations on shoreline lichens from southern British Columbia were presented by Noble (1982).

We report here on the distribution of lichen species in the upper rocky intertidal zone landward into the salt spray zone in the Gwaii Haanas area. Because splash patterns and exposure affect establishment and growth of shoreline lichens, we examined rocky shores with a range of exposures to wave action from "protected" to "very exposed" to reveal species occurrence patterns. Finally, we compared the rock-dwelling marine lichen flora and zonation of southern Haida Gwaii with the flora and patterns seen in other regions.

Study Area

Haida Gwaii, known also as the Queen Charlotte Islands, is an archipelago of about 138 islands in the hypermaritime zone of the Pacific Northwest, lying

about 80 km off the mainland British Columbia coast between Vancouver Island and southeast Alaska (Figure 1). Its geography, climate and vegetation were described in some detail in Brodo (1995).

The two largest land masses of Haida Gwaii are Graham Island to the north and Moresby Island to the south. The lower elevations of Graham Island (the eastern two-thirds) and Moresby Island (the northern third) have been disturbed by intensive logging activities, but the southern two-thirds of Moresby Island were set aside in 1988 as a National Park Reserve called Gwaii Haanas lying roughly between 52° and 53°N longitude (Figure 2) covering ca. 1470 km^2 of land and ca. 1700 km of shoreline (Sloan and Bartier 2000). The lichen studies described here mainly centre on the extreme southern end of the Park Reserve, at the tip of Moresby Island and on Kunghit Island (Figures 2 and 3).

Methods

To characterize our sample locations, we used Gwaii Haanas' shoreline classification system (Harper et al. 1994*). This is in the park's geographic information system (GIS) and is based largely upon substrate type, texture and exposure to wave action. This system was first developed in Gwaii Haanas and has since become the standard physical shoreline classification system of British Columbia (Howes et al. 1994*) and Washington State [http://www2.wadnr.gov/nearshore/index.asp]. The system has a biological zoning component in which visible lichens are coarsely grouped into a "*Verrucaria* band" (Searing et al. 1995). The British Columbia scheme has been used in broad-scale regional studies of intertidal species diversity (Zacharias and Roff 2001).

In Harper et al. (1994*), lichens are mentioned as forming conspicuous shoreline bands. There are references to the "*Verrucaria* zone" and the "white lichen zone," but the diversity of species is overlooked. For example, it is not made clear that the *Verrucaria* zone consists of nine black *Verrucaria* species and other dark lichens (Brodo and Santesson 1997), and that the white zone is caused by the dominance of *Coccotrema maritimum*, a species described from Haida Gwaii, whose closest relatives are in Asia and the southern hemisphere. It is rare in the Pacific Northwest outside Haida Gwaii and adjacent coastal regions (Brodo 1973). Other lichens of intertidal rocks also proved to be new to science and generally restricted to Haida Gwaii and nearby coastal localities. These include *Caloplaca litoricola*, *Fuscidea thomsonii*, *Verrucaria schofieldii*, *V. epimaura*, and *Porina pacifica* (Brodo 1984; Brodo and Wirth 1998; Brodo and Santesson 1997; Brodo 2004). Several other novelties remain to be formally described.

Fourteen locations within Gwaii Haanas and one on Limestone Island were sampled (Figures 2, 3). At each location, one to three transects were laid out for a total of 18 transects. A 12 m tape measure was deployed conforming closely to the rock surface and perpendicular to the high tide line. Transects usually began at the upper limit of the rockweed (*Fucus gardneri*) and barnacle (*Balanus* and *Semibalanus* spp.) zone (the "FB zone," approximating the mean high water level [MHW]) and ran landward to the point at which terrestrial vascular plants or mosses began. This distance was divided into eight or nine equal sections to give approximately nine to ten quadrat points. Because exposed, wave-splashed beaches and shallow slopes produced longer transects than those on protected, relatively steep shores, the increments of height above the FB zone from quadrat to quadrat were not uniform, nor were the distances between quadrats.

At each quadrat point, a 10×10 cm grid on transparent plastic with a hundred 1-cm^2 squares, was centered on the transect tape. All lichen species under the grid were recorded together with their coverage in percent (each square representing 1% coverage). For smooth rocks, the coverage readings were fairly accurate, but with increasing surface roughness, the estimates were correspondingly approximate. After the quadrats were sampled and the lichen data recorded, the vertical height of each quadrat above the starting point in the FB zone was recorded.

Results

The 18 transects were sorted and analyzed according to degree of shoreline exposure from Protected to Very Exposed, based on Harper et al. (1994*), as listed in Table 1. Two locations had multiple transects, there were no transects for localities 6 or 10, and transect 11 had incomplete data and was excluded. Limestone transects are indicated (L) and all other transects were over mixed volcanic and fine-grained sedimentary rocks characteristic of the region's shoreline (Sutherland Brown and Yorath 1989).

The transects in Gwaii Haanas yielded 43 lichen species. Sixty-seven rock-dwelling species occurring on maritime rocks are currently known from Haida Gwaii as a whole. An annotated list of all shoreline species in Haida Gwaii is presented as an Appendix. This updates the list in Sloan and Bartier (2000; Appendix B, Part 2) compiled by the senior author based on specimens at the National Herbarium of Canada (CANL), Ottawa. The zones indicated in Sloan and Bartier (2000) were assigned tentatively, based on label data, and have been corrected in this study. Two of the lichens from our transects (*Verrucaria striatula* and *V. sandstedei*) are new lichens for Haida Gwaii (and British Columbia), and ten others were not included in the Sloan and Bartier (2000) list because they were not regarded to be maritime. These are: *Adelolecia kolaensis, Gyalecta jenensis, Opegrapha gyrocarpa, Parmelia saxatilis, Placopsis lambii, Porpidia contraponenda, P. speirea* and *P. thomsonii.* Many relatively common maritime and marine lichens found elsewhere in Haida Gwaii were not seen in the Gwaii Haanas transects. These include *Caloplaca inconspecta,*

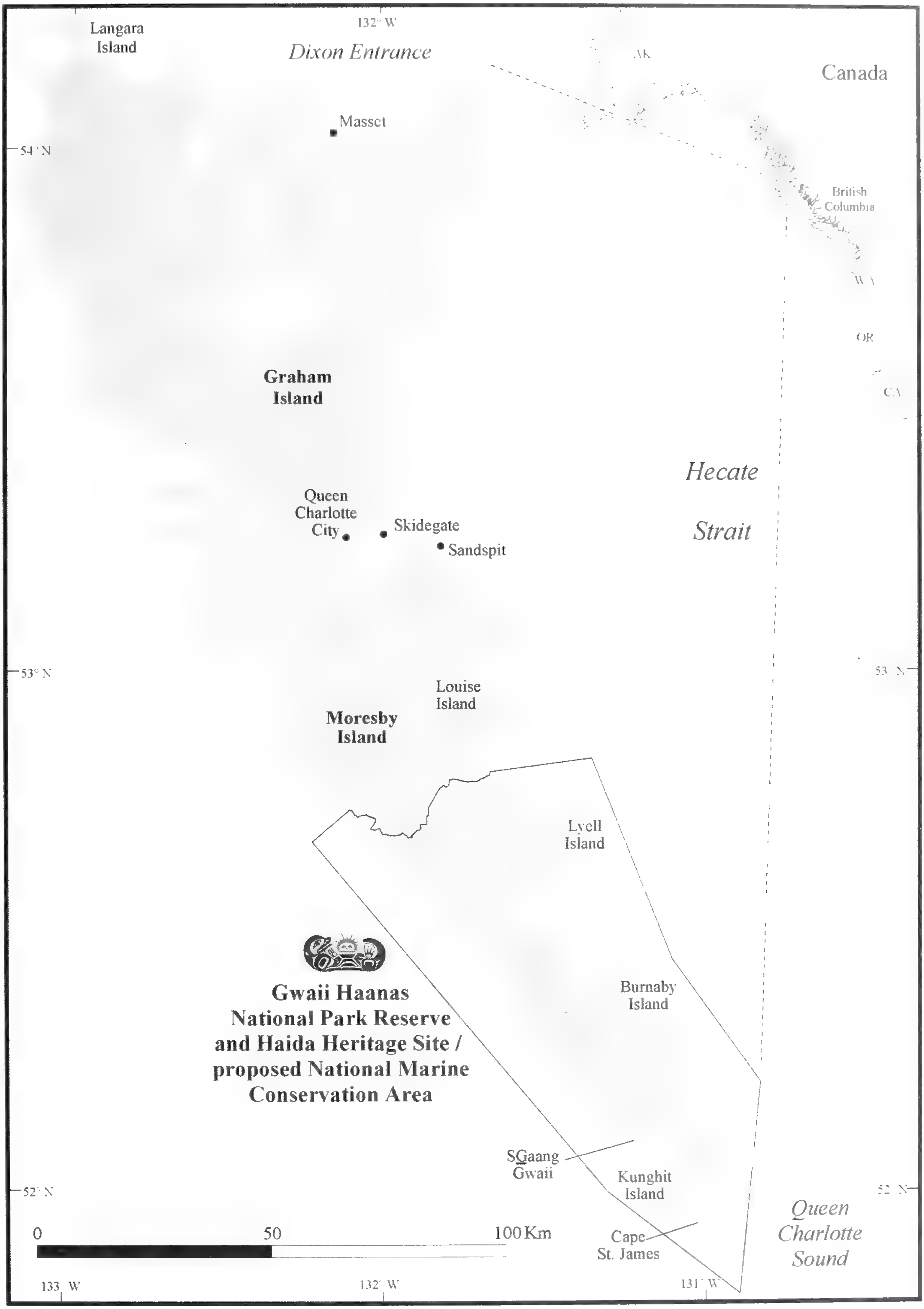


FIGURE 1. Location of Gwaii Haanas within Haida Gwaii (Queen Charlotte Islands) including some of the larger islands.

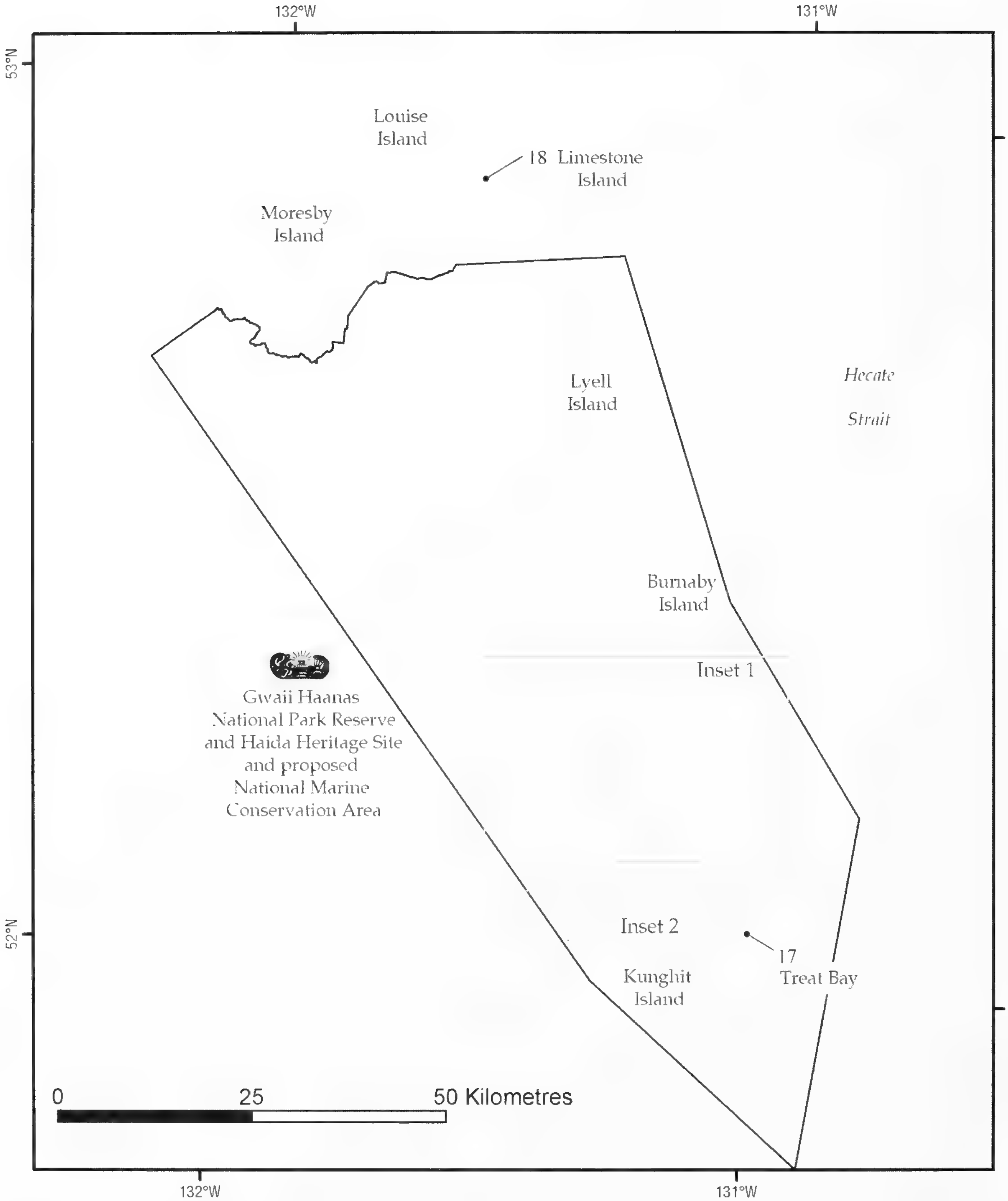
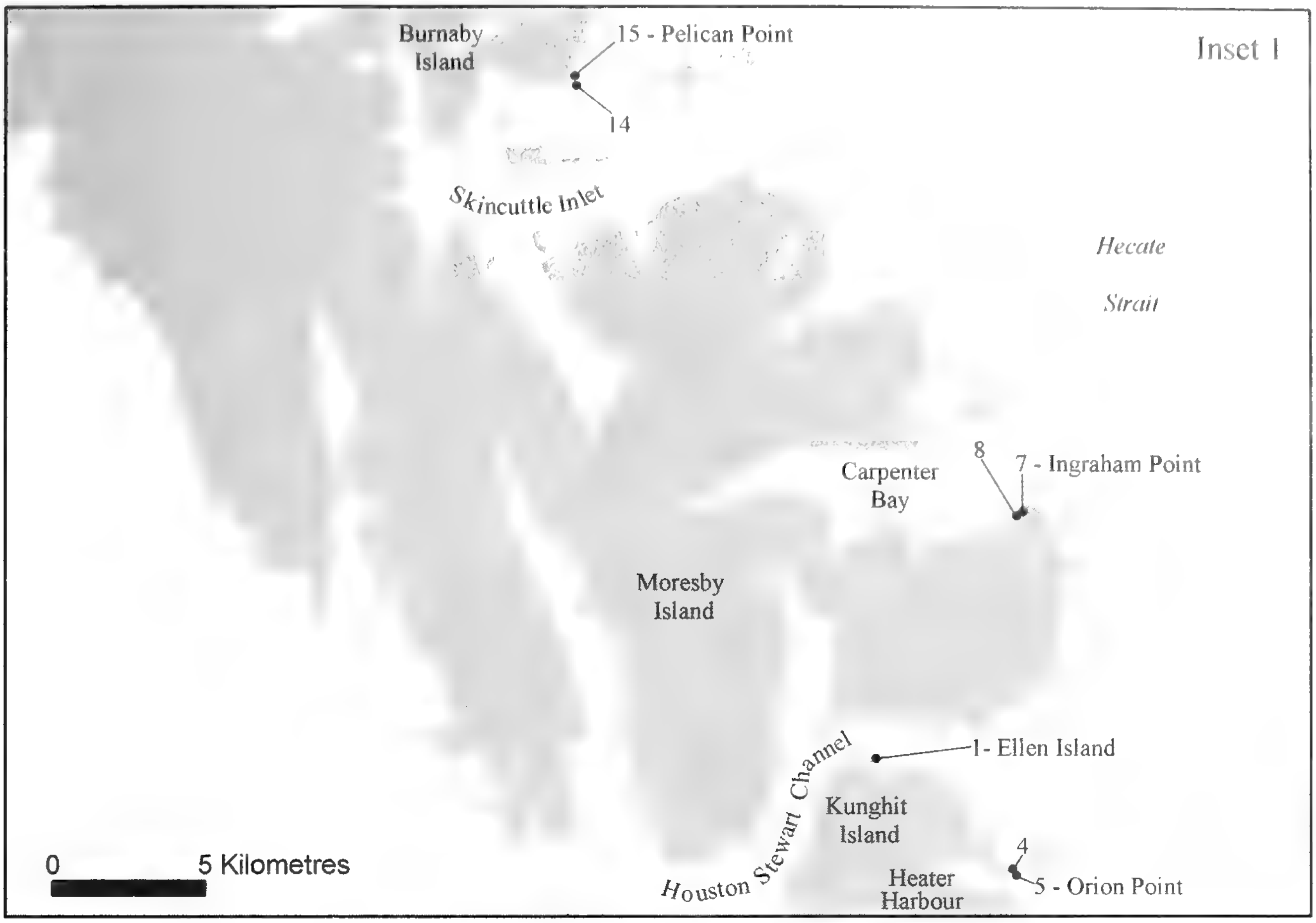


FIGURE 2. Map of the Gwaii Haanas area showing Limestone Island (location 18) to the north and Treat Bay (location 17) to the south of the insets (see Figure 3 for insets).

Catillaria calybeia, Rhizocarpon hensseniae and *Rinodina gennari.* At least one lichen (*Porina pacifica*) was found growing abundantly just outside the quadrats on a protected shore.

The frequency of occurrence (%) of each species in each transect is listed according to shore exposure class in Table 2. *Verrucaria maura* occurred in all transects on all shores. Among the eight most abundant lichens (frequencies exceeding 50% in all transects), four are endemic or nearly endemic to Haida Gwaii: *Caloplaca litoricola, Coccotrema maritimum, Verrucaria epimaura* and *V. schofieldii*; and one is endemic to the coastal Pacific Northwest (*Herteliana alaskensis*). The semi-exposed shores had the most species and the most exposed shores yielded the fewest species.

The results of the transect observations, expressed as metres above the FB (*Fucus*/barnacle) zone, are given in Tables 3 and 4 organized according to the degree of



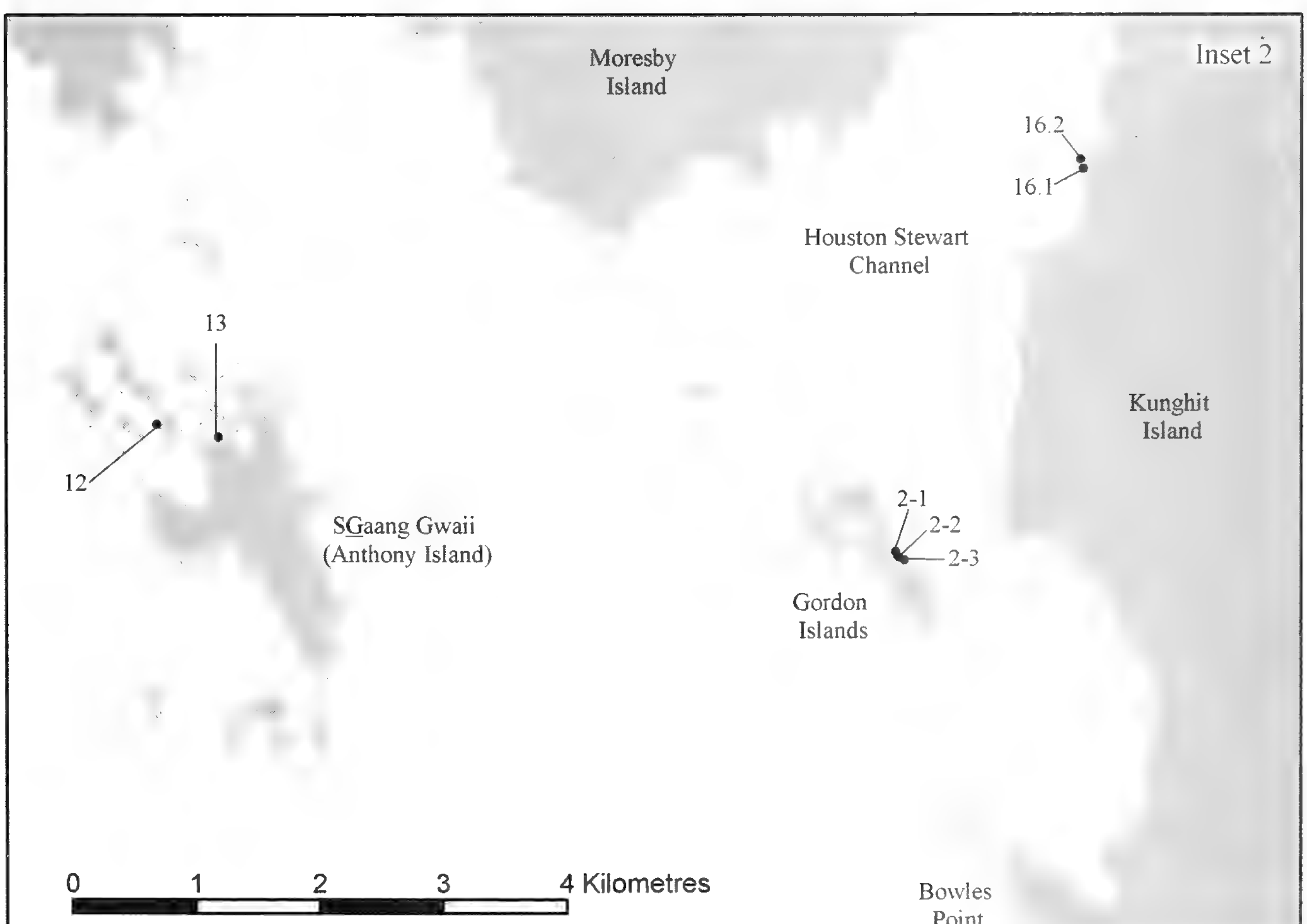


FIGURE 3. Inset maps from Figure 2 showing lichen sampling locations 1-16 within Gwaii Haanas (see Table 1).

TABLE 1. Locations of shore lichen transects in the Gwaii Haanas area grouped according to the shore exposure classification of Harper et al. (1994).

Exposure Class	Location Name	Transect No.[a]	Latitude (°N)	Longitude (°W)
Protected	Carpenter Bay	9	131.1660	52.2312
	SGaang Gwaii	13	131.2251	52.1015
	Limestone Island	18(L[b])	131.6170	52.9086
Semi-protected	Ellen Island	1	131.0918	52.1544
	Orion Point	5	131.0231	52.1229
Semi-exposed	Gordon Islands	2-1, 2-2, 2-3	131.1443	52.0967
	Orion Point	4	131.0217	52.1241
	Pelican Point	14 (L[b])	131.2615	52.3472
	Pelican Point	15	131.2618	52.3458
	Houston-Stewart Channel	16-1, 16-2	131.1261	52.1253
	Treat Bay	17	131.0080	52.0659
Exposed	Ingraham Point	7	131.0325	52.2321
	Ingraham Point	8	131.0331	52.2319
Very exposed	Gordon Islands	3	131.1493	52.0965
	SGaang Gwaii	12	131.2330	52.1021

[a] Two locations (2 and 16) had multiple transects, locations 6 and 10 had no transects, the transect at location 11 was incomplete and excluded.
[b] L = limestone rock

exposure of each shore. These data are graphed Figures in 4 and 5, with the ordination based on average minimum values (the base of the thick black line). Because the values for all shore exposures except "Very Exposed" appear to largely overlap with respect to the height above the FB zone, the data are pooled in Table 3 and Figure 4; Table 4 and Figure 5 shows the data only for Very Exposed shores. The data for Quadrat Position (Table 5), being relative, are not greatly affected by shore exposure, so all shores are considered together. The results of all transects with 8-10 quadrats per transect are shown in Figure 6. (Transects having only 6 or 7 quadrats cannot be compared with those having 8-10 transects.)

Translating the continuum of species position into a zonal scheme with names that correspond with previous North American or European studies proved to be challenging. The graphs presented in Figures 4 and 5 based on metres above the upper limit of the FB zone (Tables 3 and 4) were compared to Figure 6 showing the species according to their quadrat placement along the transects (Table 5) with the aim of finding natural breaks in the continua. This was only partially successful. Thus, in Table 6, which presents a summary of the zones, their position and their dominant lichens, a few species are listed twice, in different zonal categories, according to height above the *Fucus*-barnacle limit versus their relative quadrat position. Our zonal terminology basically follows the British System, especially Fletcher (1973a, 1973b) who, in agreement with Lewis (1961), argued that the zones are best described and defined on biological criteria, not on physical (i.e., tidal) criteria. Lewis (1961) recommended adopting "Littoral Fringe" in place of "Supralittoral Fringe" used by Stephenson and Stephenson (1949) because it better describes the community that inhabits the upper fringe of the intertidal zone, washed by most tides in relatively protected shorelines. We replace Mesic, Submesic and Xeric subdivisions of the Supralittoral Zone with the more easily understood terms Lower, Middle and Upper, respectively. In addition, we find that the term "xeric," even taken in its relative sense, is not an accurate description of a shoreline habitat. Ryan (1988b) used a numbering system for his zones, but they basically followed the British scheme following the distribution of shoreline organisms. O'Clair et al. (1996) used a simplified system based on wave exposure, and this was adopted by Sloan and Bartier (2000). Some zonal synonymy, discussed in detail by Ryan (1988b), is given in the first column of Table 6.

In the Gwaii Haanas area, *Verrucaria mucosa* and *Pyrenocollema halodytes* are the most abundant species at the upper edge of the intertidal zone; i.e., the lowest point on our transects, where rockweed or barnacles occur (Lower Littoral Fringe; quadrat 1). They grow there together with some of the smaller and rarer species of *Verrucaria* such as *V. sandstedei* and *V. striatula*. These are generally too small, thin, and scattered to create a black zone and, therefore, are hard to find. The black zone begins with the appearance of the blacker, thicker species of *Verrucaria: V. erichsenii, V. maura, V. epimaura* and *V. schofieldii*, all of which can have broad coverage (Table 7) in the Upper Littoral Fringe (quadrats 2-4). Although *V. maura* continues to be important well up on the shoreline, the community changes its character and color with the appearance of the gray-brown, gray, and orange species such as *Herteliana alaskensis, Arthonia phaeobaea,* and the near-endemic but abundant Haida Gwaii lichen, *Caloplaca litoricola,* in the Lower Supralittoral Zone (quadrats 5-7). Also in this zone is *Adelolecia kolaensis* and the cyanophilic lichen *Spilonema revertens.* Above this is a poorly defined orange zone (Middle Supra-

TABLE 2. Percentage occurrence of shoreline lichen species at locations according to shore exposure classification of Harper et al. (1994) in the Gwaii Haanas area. P = protected; SP = semi-protected; SE = semi-exposed; E = exposed; VE = very exposed.

	% occurrence according to shore exposure class (number of transects)					%
Lichen species	P (3)	SP (2)	SE (9)	E (2)	VE (2)	occurrence in all transects
Verrucaria maura	100	100	100	100	100	100
Spilonema revertens	67	100	56	100	50	67
Caloplaca litoricola	33	100	56	100	50	61
Coccotrema maritimum	67	50	67	100	0	61
Verrucaria epimaura	0	100	67	50	100	61
Herteliana alaskensis	67	100	33	100	50	56
Pyrenocollema halodytes	67	0	56	50	100	56
Verrucaria schofieldii	67	100	56	0	0	50
Arthonia phaeobaea	33	50	33	100	50	44
Verrucaria amphibia	100	0	33	50	0	39
Lecidella stigmatea	67	100	0	0	100	33
Rhizocarpon geminatum	33	50	22	0	50	28
Xanthoria candelaria	0	50	22	0	100	28
Amandinea coniops	0	100	22	0	0	22
Physcia caesia	33	50	22	0	0	22
Porpidia speirea	0	0	44	0	0	22
Verrucaria erichsenii	0	0	33	0	50	22
Verrucaria mucosa	67	0	22	0	0	22
Caloplaca flavogranulosa	33	0	22	0	0	17
Collema fecundum	33	0	11	50	0	17
Fuscidea thomsonii	0	0	22	50	0	17
Adelolecia kolaensis	33	50	0	50	0	17
Verrucaria degelii	0	0	33	0	0	17
Verrucaria sandstedei	0	0	33	0	0	17
Lecanora muralis	0	50	0	0	50	11
Ochrolechia subplicans	0	0	11	50	0	11
Parmelia saxatilis	0	0	11	50	0	11
Placopsis lambii	0	0	22	0	0	11
Porpidia thomsonii	0	0	11	50	0	11
Rhizocarpon haidensis ined.	0	0	22	0	0	11
Aspicilia caesiocinerea	0	50	0	0	0	6
Caloplaca citrina	0	0	11	0	0	6
Caloplaca rosei	0	50	0	0	0	6
Caloplaca verruculifera	0	0	0	0	50	6
Candelariella sp.	0	50	0	0	0	6
Fuscopannaria maritima	0	0	11	0	0	6
Gyalecta jenensis	0	0	11	0	0	6
Lecanora sp. #2	0	50	0	0	0	6
Lecanora sp. #1	0	50	0	0	0	6
Lecanora straminea	0	0	0	0	50	6
Opegrapha gyrocarpa	33	0	0	0	0	6
Opegrapha sp.	0	0	11	0	0	6
Porina pacifica	33	0	0	0	0	6
Porpidia carlottiana	0	50	0	0	0	6
Porpidia contraponenda	0	0	11	0	0	6
Rhizocarpon hochstetteri s. str	33	0	0	0	0	6
Verrucaria sp. #5	0	0	11	0	0	6
Verrucaria striatula	0	0	0	0	50	6
Total lichen species	19	21	33	15	15	

littoral Zone; quadrats 7-8) with *Caloplaca flavogranulosa, C. rosei* (both west coast endemics) and the widespread *Xanthoria candelaria*, as well as the inconspicuous crust, *Rhizocarpon* "*haidensis.*" The Upper Supralittoral Zone (quadrats 8 – 9) almost at the upper edge of the beach is well marked by the dominance of the pinkish white lichen, *Coccotrema maritimum*, which forms a conspicuous white band on the coastal rocks of Haida Gwaii, especially on the Pacific side, although it is less common outside of the archipelago. Accompanying the *Coccotrema* are such widespread lichens as *Placopsis lambii*, various species of *Rhizocarpon*, and rarer west coast species such as *Ochrolechia subplicans*. Higher on the shore and influ-

TABLE 3. Summary data for Protected to Exposed shores, metres above *Fucus*/barnacle zone (16 quadrats).

Species	# quadrants	Extreme minimum	Average minimum (m)	Average maximum (m)	Extreme maximum (m)
Adelolecia kolaensis	3	1.35	1.43	2.03	3.15
Arthonia phaeobaea	7	0.55	1.04	1.34	2.40
Aspicilia caesiocinerea	1	2.05	2.05	3.15	3.15
Caloplaca citrina	1	1.05	1.05	1.05	1.05
Caloplaca flavogranulosa	3	1.24	1.85	1.85	2.20
Caloplaca litoricola	10	0.55	1.07	1.43	3.15
Caloplaca rosei	1	2.05	2.05	2.65	2.65
Candelariella sp.	1	2.65	2.65	2.65	2.65
Coccotrema maritimum	11	1.10	2.05	2.32	3.60
Collema fecundum	3	0.80	1.40	1.50	1.90
Fuscidea thomsonii	3	2.20	2.73	2.73	3.60
Fuscopannaria maritima	1	2.40	2.40	2.40	2.40
Gyalecta jenensis	1	0.90	0.90	0.90	0.90
Herteliana (Bacidia) alaskensis	9	0.60	1.08	1.20	2.45
Lecanora muralis	2	2.65	2.65	2.65	2.65
Lecanora sp. no.1	1	0.55	0.55	0.55	0.55
Lecanora sp. no.2	1	0.90	0.90	0.90	0.90
Lecidella stigmatea	4	0.60	1.25	1.30	2.05
Ochrolechia subplicans	2	1.80	2.10	2.40	2.40
Opegrapha gyrocarpa	1	1.83	1.83	1.83	1.83
Opegrapha sp.	1	1.80	1.80	2.30	2.30
Parmelia saxatilis	2	2.00	2.20	2.20	2.40
Physcia caesia	4	1.00	1.11	1.99	3.15
Placopsis lambii	2	1.85	1.93	2.13	2.40
Porina pacifica	*1*	*2.70*	2.70	3.60	3.60
Porpidia carlottiana	1	1.50	1.50	1.50	1.50
Porpidia contraponenda	1	1.60	1.60	1.60	1.60
Porpidia speirea	4	1.10	2.28	2.44	3.60
Porpidia thomsonii	2	2.00	2.05	2.05	2.10
Pyrenocollema halodytes	8	-0.20	0.00	0.00	0.35
Rhizocarpon geminatum	4	1.70	2.53	2.61	3.15
Rhizocarpon haidensis	2	1.25	2.08	2.55	2.90
Rhizocarpon hochstetteri s. str	1	1.30	1.30	1.30	1.30
Spilonema revertens	11	0.60	1.65	2.21	3.60
Verrucaria amphibia	7	0.20	0.44	0.61	0.69
Verrucaria degelii	3	0.30	0.32	0.32	0.35
Verrucaria epimaura	9	0.25	0.45	0.81	2.25
Verrucaria erichsenii	3	0.00	0.35	0.87	0.90
Verrucaria maura	16	-0.20	0.45	1.93	3.60
Verrucaria mucosa	4	-0.20	-0.05	0.08	0.20
Verrucaria sandstedei	3	0.00	0.20	0.33	0.35
Verrucaria schofieldii	9	-0.15	0.62	0.78	1.50
Verrucaria sp. #5	1	0.90	0.90	1.05	1.05
Xanthoria candelaria	3	1.40	1.97	2.33	3.65

enced only by intermittent salt spray, is the Terrestrial Zone (quadrats 9-10), characterized by widespread non-maritime but salt-tolerant species such as *Parmelia saxatilis* as well a Haida Gwaii endemic, *Fuscidea thomsonii*, and a few lichens restricted to the Pacific Northwest, such as *Fuscopannaria maritima* and *Porpidia carlottiana*. The bird rock community (ornithocoprophilous lichens), including *Lecanora straminea, L. muralis,* and *Caloplaca verruculifera,* also occurs in this zone.

In comparing the graph showing zonation on Protected to Exposed shores (Figure 4) with the graph dealing with Very Exposed shores (Figure 5), it is immediately apparent that on very exposed shorelines, most of the lichen species are much higher on the shore, the zones themselves are much broader (reflecting the height of wave splash), and not all species are in the same relative quadrat position. For example, the cyanobacterial lichen, *Spilonema revertens*, which mainly occurs in the central section of the transects (Middle Supralittoral) on Protected to Exposed shores, is found at the top of the transects (Terrestrial) on Very Exposed shores. *Verrucaria maura* begins to invade the rock over a metre above the *Fucus*/barnacle limit, and other shoreline lichens are proportionally higher on the shore. The five species at the top of the transects are terrestrial, but salt-tolerant, lichens, not really maritime. Also unique to the Very Exposed shores are the

TABLE 4. Summary data for Very Exposed shores, metres above *Fucus*/barnacle zone (2 transects).

Species	# quadrants	Extreme minimum	Average minimum (m)	Average maximum (m)	Extreme maximum (m)
Arthonia phaeobaea	1	2.05	2.05	2.05	2.05
Caloplaca litoricola	1	2.05	2.05	3.65	3.65
Caloplaca verruculifera	1	3.65	3.65	3.65	3.65
Herteliana alaskensis	1	3.65	3.65	3.65	3.65
Lecanora muralis	1	6.70	6.70	6.70	6.70
Lecanora straminea	1	3.65	3.65	3.65	3.65
Lecidella stigmatea	2	2.75	4.73	4.83	6.70
Pyrenocollema halodytes	2	0.00	0.00	0.00	0.00
Rhizocarpon geminatum	1	6.70	6.70	6.70	6.70
Spilonema revertens	1	5.70	5.70	6.70	6.70
Verrucaria epimaura	2	1.75	2.23	2.38	2.70
Verrucaria erichsenii	1	0.70	0.70	1.70	1.70
Verrucaria maura	2	1.10	1.40	4.83	6.70
Verrucaria schofieldii	1	1.10	1.10	1.10	1.10
Verrucaria striatula	1	0.00	0.00	0.00	0.00
Xanthoria candelaria	2	3.65	5.18	5.18	6.70

large areas of uncolonized rock (bare of lichens as well as barnacles or marine algae).

The relative zonal position of some lichen species on protected shores differs when comparing relative quadrat position and actual distance above the FB zone (compare Figures 4 and 6). This may be due to the ability of these species to occupy broader zones than others, coupled with the method of averaging minimum and maximum values to draw the charts. The species included in more than one zonal category are marked with an asterisk (*) or exclamation (!) in Table 6.

Species richness (diversity) appears to be greatest on Semi-exposed shores (33 species) but, since this category of exposure has the largest number of transects (9), the significance of this number is difficult to evaluate. If one combines the lists in Table 2 for Protected and Semi-protected shores (5 transects) and those of Exposed and Very Exposed shores (4 transects), the numbers of species are closer: P+SP: 29 species; SE: 33 species; E+VE: 23 species. Interestingly, the Very Exposed shores, with only 16 species, include 3 species found in no other exposure type, *Verrucaria striatula, Caloplaca verruculifera* and *Lecanora straminea.*

One indication of species importance along the rocky shores is the ability of each species to form large patches, i.e., with high coverage values. Table 7 summarizes the coverage classes of all the species that appeared in quadrats in this study. Some species, and even species groups, are clearly able to cover larger areas than others. Almost all the black *Verrucaria* species, for example, are able to cover over 50% of the 100 cm^2 quadrats, which is why they form a conspicuous black belt on the shore. Similarly, *Coccotrema maritimum* forms large patches as does *Caloplaca litoricola* and *Ochrolechia subplicans*. Some species never dominate their zones, however, always occurring in small patches even if they are frequently encountered. Examples are *Spilonema revertens, Pyrenocollema halodytes, Herteliana alaskensis* and *Arthonia phaeobaea.*

Rock type generally has a major influence on species composition in lichen communities, but some species are more tolerant of varying rock type than others. *Verrucaria mucosa* was especially abundant on limestone although present on siliceous rock as well. Some lichens found only, or most commonly, on the limestone transects were *Verrucaria amphibia, V.* species number 5, *Caloplaca citrina* and *Gyalecta jenensis. Pyrenocollema halodytes* occurs on limestone rocks as well as on barnacles (both rich in calcium carbonate). On the other hand, many common lichens; e.g., *Coccotrema maritimum, Caloplaca litoricola, Verrucaria epimaura, Herteliana alaskensis* and *Collema fecundum*, were found only on siliceous rock. Species apparently oblivious to rock chemistry include *Verrucaria maura* and *V. schofieldii.*

Discussion

Marine and maritime lichens distribute themselves on rocky shorelines in response to many factors, with the dominant influences being wave exposure and, particularly, immersion duration (Southward 1958; Fletcher 1973a; Taylor 1982). Fletcher (1973a) said that lichens such as *Verrucaria mucosa* and *V. striatula,* which grow among the barnacles in the upper intertidal zone, require 52% submergence per year, the highest amount for any lichen. There is experimental evidence (Ramkaer 1977) that spore germination and hyphal growth at young stages of development are influenced by salt concentrations, and that the ability of different lichens to become established in shoreline habitats is positively correlated with their position on shoreline rocks. Those lowest on the shore (longest immersion duration) are the species that have best germination and hyphal growth under moderate or even high concentrations of seawater. Mature thalli

Table 5. Summary data for relative quadrat position for all transects with 8-10 quadrats (15 transects).

Species	# quadrants	Extreme minimum	Average minimum (m)	Average maximum (m)	Extreme maximum (m)
Adelolecia kolaensis	3	4.00	5.67	7.00	8.00
Amandinea coniops	4	6.00	6.50	6.50	7.00
Arthonia phaeobaea	7	4.00	6.00	6.57	9.00
Aspicilia caesiocinerea	1	6.00	6.00	8.00	8.00
Caloplaca flavogranulosa	3	6.00	7.33	7.33	8.00
Caloplaca litoricola	10	4.00	4.80	6.30	9.00
Caloplaca rosei	1	7.00	7.00	7.00	7.00
Caloplaca verruculifera	1	9.00	9.00	9.00	9.00
Candelariella sp.	1	7.00	7.00	7.00	7.00
Coccotrema maritimum	9	6.00	8.00	9.00	10.00
Collema fecundum	3	5.00	6.00	6.67	7.00
Fuscidea thomsonii	3	9.00	9.33	9.33	10.00
Fuscopannaria maritima	1	9.00	9.00	9.00	9.00
Herteliana alaskensis	10	3.00	4.80	5.30	9.00
Lecanora muralis	2	7.00	7.50	7.50	8.00
Lecanora straminea	1	9.00	9.00	9.00	9.00
Lecanora sp. no.1	1	4.00	4.00	4.00	4.00
Lecanora sp. no.2	1	3.00	3.00	3.00	3.00
Lecidella stigmatea	6	4.00	6.17	6.67	8.00
Ochrolechia subplicans	2	7.00	8.00	9.00	9.00
Opegrapha gyrocarpa	1	8.00	8.00	8.00	8.00
Parmelia saxatilis	2	6.00	8.50	9.00	9.00
Physcia caesia	3	6.00	6.00	7.00	8.00
Placopsis lambii	2	8.00	8.00	8.50	9.00
Porina pacifica	1	7.00	7.00	8.00	8.00
Porpidia carlottiana	1	9.00	9.00	9.00	9.00
Porpidia speirea	3	6.00	8.00	8.67	10.00
Porpidia thomsonii	2	8.00	8.00	8.00	8.00
Pyrenocollema halodytes	9	1.00	1.00	1.00	1.00
Rhizocarpon geminatum	5	5.00	7.80	8.00	9.00
Rhizocarpon haidensis	2	7.00	7.00	9.50	10.00
Rhizocarpon hochstetteri s. str	1	8.00	8.00	8.00	8.00
Spilonema revertens	11	5.00	6.27	7.73	10.00
Verrucaria amphibia	5	1.00	2.40	2.60	4.00
Verrucaria degelii	2	1.00	1.00	1.00	1.00
Verrucaria epimaura	10	2.00	2.90	3.90	5.00
Verrucaria erichsenii	4	1.00	2.25	4.50	7.00
Verrucaria maura	15	1.00	2.47	7.27	10.00
Verrucaria mucosa	2	1.00	1.00	1.50	2.00
Verrucaria sandstedei	3	1.00	1.00	1.67	3.00
Verrucaria schofieldii	8	1.00	3.25	4.00	7.00
Verrucaria striatula	1	1.00	1.00	1.00	1.00
Xanthoria candelaria	5	6.00	7.20	7.60	8.00

might be affected by osmotic problems, acidity (sea water has a relatively high pH), and other seawater minerals. Other factors that influence zonation include degree of wetness and seepage of acidic fresh water from the land above the shore (Fletcher 1973b; Ryan 1988b) and excess heating or freezing (Southward 1958). *Verrucaria maura* occurs far up on exposed shores in depressions or shaded nooks indicating a requirement for moisture. This was noted by European workers, including Fletcher (1973b), who nevertheless regards *V. maura* as one of the more drought-tolerant of the marine *Verrucaria* species. Fletcher (1973a) found that *V. maura* actually has no requirement for submergence in sea water at all. It can survive with only sea spray. Competition with algae and grazing animals (such as limpets and snails) is regarded to be a significant factor by some observers (Southward 1958; Ryan 1988b) and minimal by others (Fletcher 1973a). We did not see much evidence of grazing on the lichens of Gwaii Haanas.

As noted by Fletcher (1980), the lichen bands can be characterized by life form as well as species. In the Littoral Fringe, all lichens are anatomically unstratified (i.e., without a differentiated cortex, algal layer and medulla) and almost all open by an ostiole rather than having a discoid apothecium. An exception in Gwaii Haanas is *Herteliana alaskensis*, a lichen with biatorine apothecia found in the Lower Supralittoral Zone

TABLE 6. Zones formed by lichens on maritime rocks in Gwaii Hanaas. The names of equivalent zones in O'Clair et al. (1996) and Ryan (1988b) are also given. For species listed twice under "Characteristic lichens," an asterisk (*) indicates the lichen's zonal position according to its occurrence in the quadrat series (see Figure 6); an exclamation (!) indicates its zonal position according to its height above the *Fucus*-barnacle (FB) zone (see Figure 4). P to E = protected to exposed shores; VE = very exposed shores.

Zone Type	Quad series Quadrat	m above FB zone	Characteristic lichens P to E	Characteristic lichens VE
Terrestrial (Halophilic)	9-10	2.3-3.6	*Parmelia saxatilis*	
O'Clair: upper salt spray			*Fuscidea thomsonii*	
Ryan: Zones 2A- 2B			*Fuscopannaria maritima*	
			Rhizocarpon geminatum!	*Rhizocarpon geminatum*
			Lecanora muralis!	*Lecanora muralis*
			Porina pacifica	*Spilonema revertens*
			*Caloplaca verruculifera**	
			*Lecanora straminea**	
			Porpidea speirea!	
Upper Supralittoral Zone	8-9	2.1-2.6	*Coccotrema maratimum*	
O'Clair: mid salt spray			*Placopsis lambii*	
Ryan: Zone 2C-2D			*Ochrolechia subplicans*	*Lecidella stigmatea*
			Xanthoria candelaria!	*Xanthoria candelaria*
			Porpidia thomsonii	
			Aspicilia caesiocinerea	
			Rhizocarpon "haidensis"!	
			Caloplaca rosei!	
			*Porpidea speirea**	
			*Rhizocarpon geminatum**	
Middle Supralittoral Zone	7-8	1.4-2.3	*Caloplaca flavogranulosa*	
O'Clair: low salt spray			*Caloplaca rosei**	*Caloplaca verruculifera*
Ryan: Zone 2D			*Rhizocarpon "haidensis"**	*Herteliana alaskensis*
			*Lecanora muralis**	*Lecanora straminea*
			*Xanthoria candelaria**	
			Adelolecia kolaensis!	
			Spilonema revertens!	
Lower Supralittoral Zone	5-7	0.8-1.5	*Herteliana alaskensis*	
O'Clair: splash zone			*Caloplaca litoricola*	*Caloplaca litoricola*
Ryan: Zone 2E			*Arthonia phaeobaea*	*Arthonia phaeobaea*
			Physcia caesia	*Verrucaria maura*
			Collema fecundum	*V.epimaura*
			*Adelolecia kolaensis**	
			*Spilonema revertens**	
Littoral Fringe, Upper	2-4	0.3-0.8	*Verrucaria maura*	
O'Clair : high intertidal (p.p.)			*Verrucaria epimaura*	
Ryan: Zone 3-2E			*Verrucaria erichsenii*	*Verrucaria erichsenii*
			Verrucaria schofieldii	*V. schofieldii*
			Verrucaria amphibia	
Littoral Fringe, Lower	1-2	-0.3-0.3	*Pyrenocollema halodytes*	*Pyrenocollema halodytes*
O'Clair: high intertidal (p.p.)			*Verrucaria striatula*	*Verrucaria striatula*
Ryan: Zone 4A-3			*Verrucaria mucosa*	
			Verrucaria sandstedei	

occasionally in the company of black species of *Verrucaria.* Lichens with apothecia, also having somewhat stratified crustose thalli, first appear in the Lower Supralittoral Zone. Higher still, in the Middle and Upper Supralittoral Zones, the stratified foliose lichens appear. The biological reasons for this phenomenon are fairly easy to surmise. Lichens that are submerged frequently have no need for a loosely organized medulla with air spaces for gas exchange, and their spores are better distributed by oozing out of an ostiole than being shot into the air as would occur from an apothecial disk. Stratified apothecial lichens are adapted for a basically terrestrial life style.

The shift in relative position in the zonation by *Spilonema revertens* on Very Exposed (where it is Terrestrial) as compared to less exposed shorelines

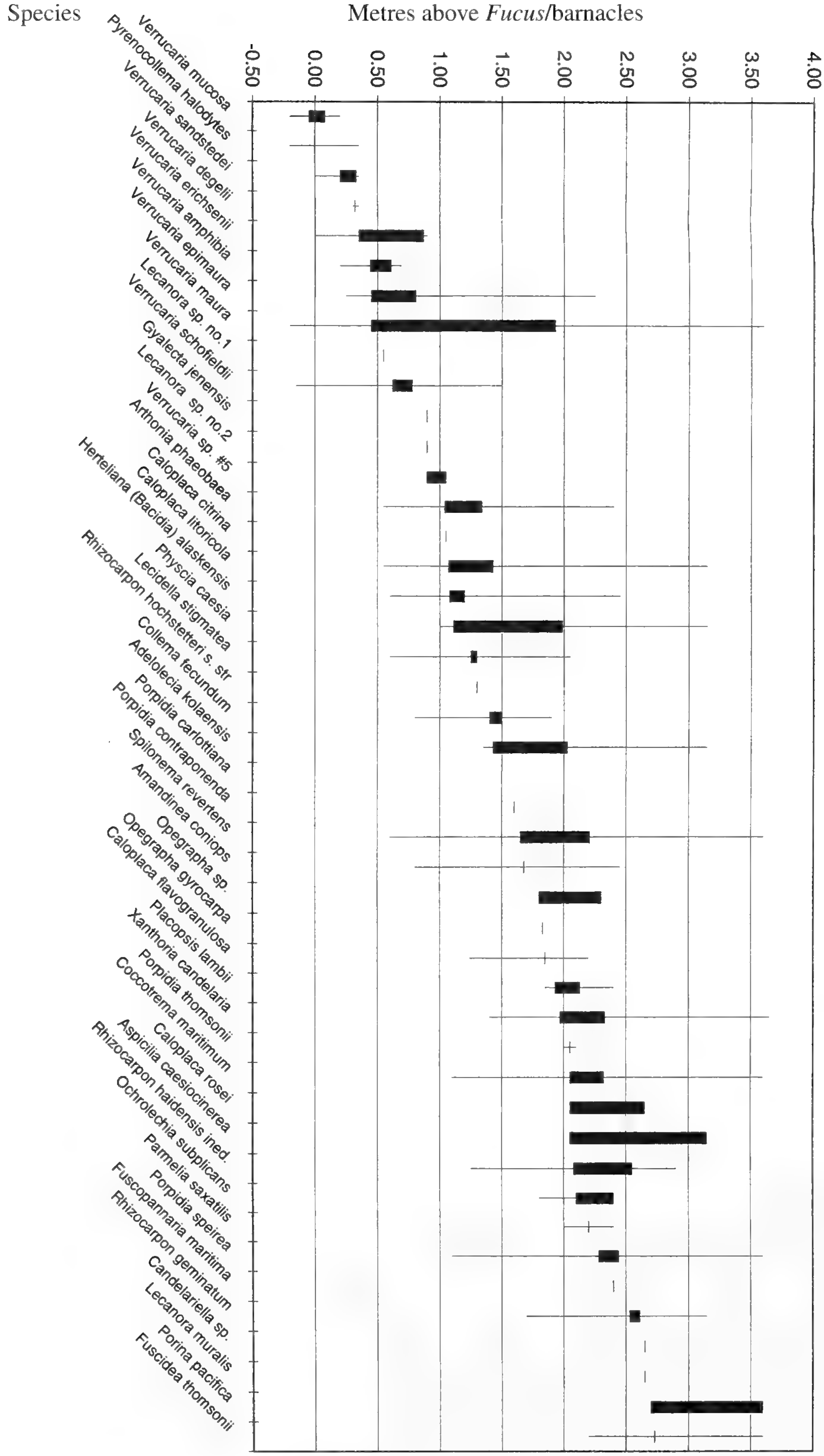


FIGURE 4. Zonation of maritime lichens on Protected to Exposed shores, ordered by metres above the *Fucus*-barnacle zone. The thick line is the range of average values. The thin lines represent the total range (extreme maximum and minimum) values.

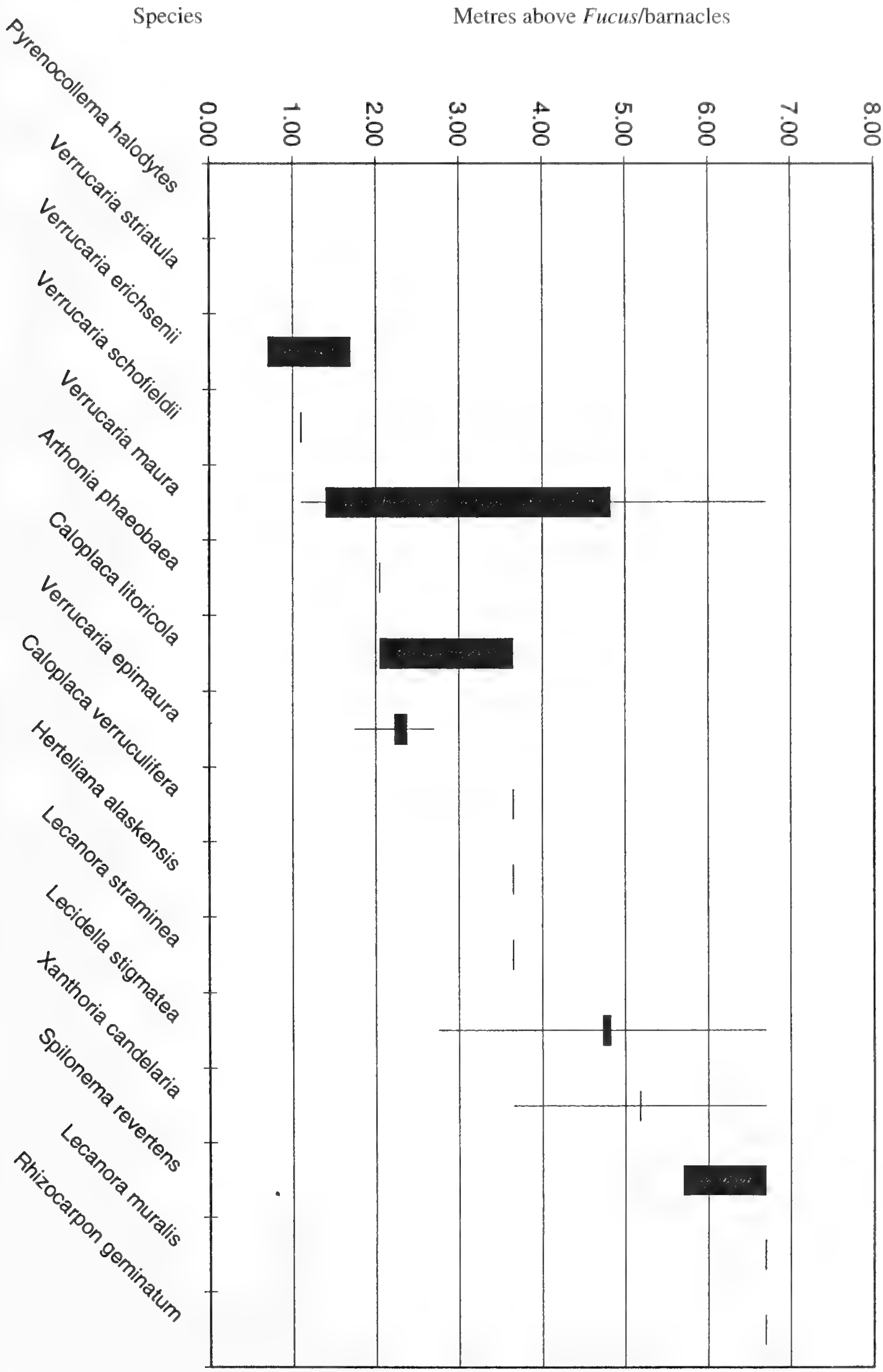


FIGURE 5. Zonation of maritime lichens on Very Exposed shores, ordered by metres above the *Fucus*-barnacle zone. The thick line is the range of average values. The thin lines represent the total range (extreme maximum and minimum) values.

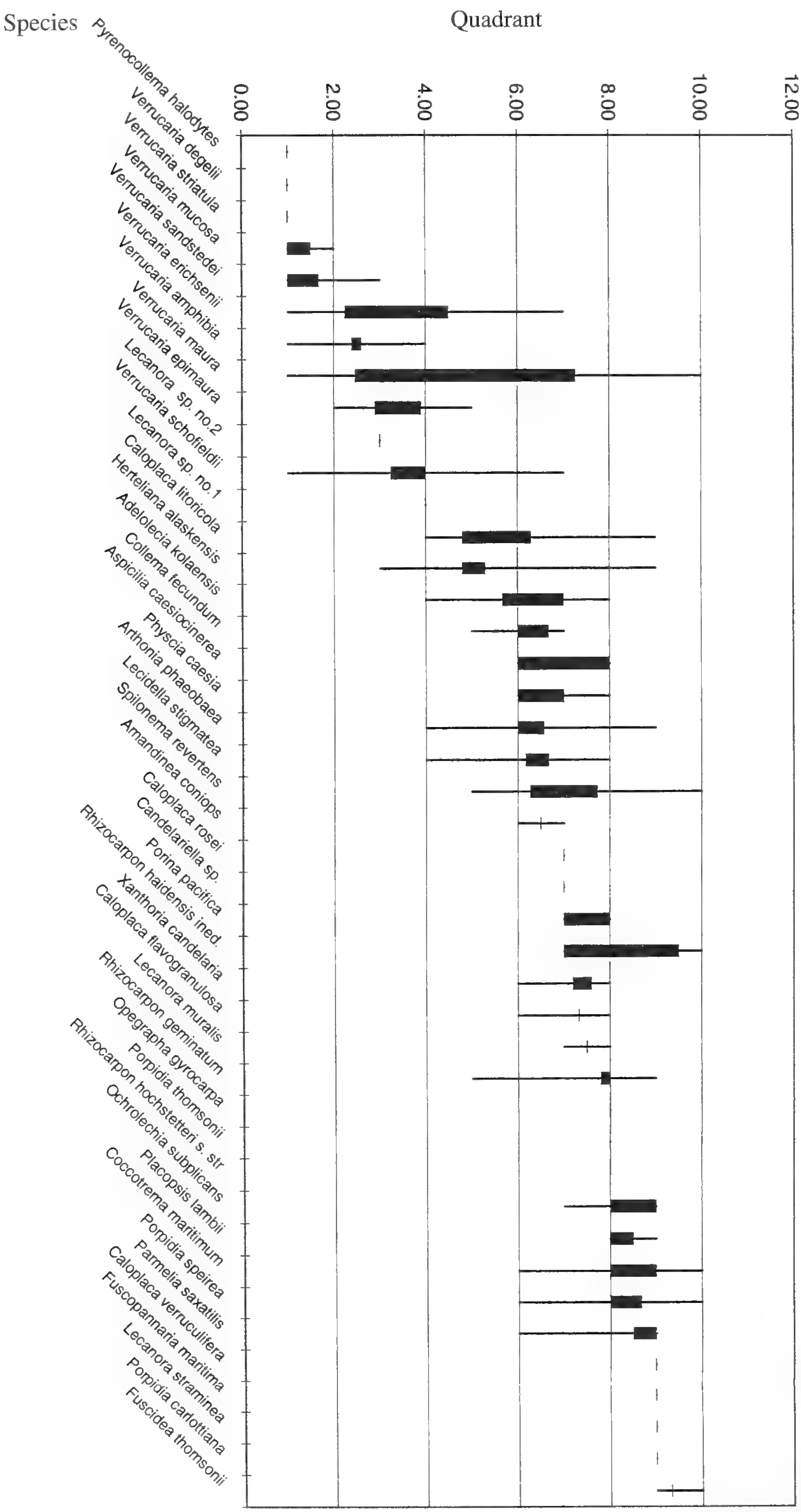


FIGURE 6. Zonation of maritime lichens on Protected to Very Exposed shores, ordered by relative quadrat position. The thick line is the range of average values. The thin lines represent the total range (extreme maximum and minimum) values.

TABLE 7. The number of quadrats sampled in which lichen species are represented, according to percentage coverage category.

	Coverage category (%)										
Lichen species	1-5	6-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Adelolecia kolaensis	4	1	2								
Amandinea coniops	3										
Arthonia phaeobaea	5	1	1								
Aspicilia caesiocinerea		1	1	1							
Caloplaca citrina				1							
Caloplaca flavogranulosa	1	1		1							
Caloplaca litoricola	6	4	3	2	1				1		
Caloplaca rosei	2										
Caloplaca verruculifera			1								
Candelariella sp.	1										
Coccotrema maritimum	1		4	2	6		2	2	1		
Collema fecundum	3	2									
Fuscidea thomsonii			3								
Fuscopannaria maritima	1										
Gyalecta jenensis			1								
Herteliana alaskensis	7	4		3							
Lecanora muralis	2										
Lecanora straminea				1							
Lecanora sp. #1								1			
Lecanora sp. #2	1										
Lecidella stigmatea	4	2									
Ochrolechia subplicans	1		1			1	1				
Opegrapha gyrocarpa			1								
Opegrapha sp.			2								
Parmelia saxatilis			2								
Physcia caesia	1		4								
Placopsis lambii	2	1									
Porina pacifica											
Porpidia carlottiana									1		
Porpidia contraponenda	1										
Porpidia speirea	4	1									
Porpidia thomsonii	1		1								
Pyrenocollema halodytes	10										
Rhizocarpon geminatum	3	1	2								
Rhizocarpon haidensis ined.	2	1	1								
Rhizocarpon hochstetteri s. str				1							
Spilonema revertens	17	2	1								
Verrucaria amphibia	2	1				2			1		3
Verrucaria degelii		1								1	
Verrucaria epimaura	2	3	4	2	3	1					
Verrucaria erichsenii	1	1	3	1		3				1	1
Verrucaria maura	11	12	8	13	3	5	8	4	12	8	4
Verrucaria mucosa		1			2	1				2	
Verrucaria sandstedei		1				1				1	
Verrucaria schofieldii	2		2	2	3	1			1	1	
Verrucaria striatula		1	1								
Verrucaria sp. #5									1	1	
Xanthoria candelaria	4				1						

(where it is Middle Supralittoral) may be due, in part, to the species' sensitivity to excessive inundation by tidal splash. More likely, it is due to its inability to physically withstand the pounding of waves on highly exposed headland rocks. *Spilonema* is a microfruticose lichen and is attached to the rock relatively loosely compared to its crustose neighbours. A similar shift in the distribution of the fruticose *Lichina pygmaea* occurs on European shores (Fletcher 1973a). *Spilonema revertens* is not a particularly maritime lichen, however, being frequently found in inland areas (Brodo et al. 2001).

The species diversity on protected and semiprotected Gwaii Haanas shores is not significantly lower than that of more exposed shores. Chu et al. (2000) found the opposite on Hong Kong shores. They hypothesized that wave-exposed shores have more microhabitats to be exploited than do quiet bays. Our data do not sup-

port Chu's observations, but our data suffer from uneven sampling in the various exposure categories and may not be as reliable.

Light influences species composition especially on the more terrestrial shoreline habitats (Fletcher 1973a). For example, *Caloplaca* and *Xanthoria* species are almost entirely restricted to sunny rocks in Gwaii Haanas. Fletcher (1973a) found that most lichens in the Littoral Fringe and even the Lower Supralittoral Zone are largely indifferent to light conditions, but Ryan (1988b) reported that *Verrucaria mucosa* only occurs in shaded habitats. This species was found in both unshaded and shaded sites in Gwaii Haanas, although it was more abundant on shaded limestone. Since exposure to sun affects moisture availability and retention, some correlation of species distribution according to shade conditions is to be expected. Shaded shores are almost always also protected shores, so it is difficult to separate the two factors in explaining differences in lichen vegetation.

Shoreline rocks are frequently subject to manuring by sea birds, increasing the nitrogen load (urea and ammonia) and raising the pH of the rock surface, and this affects the composition of the saxicolous lichen communities, especially in the salt spray zone. Ornithocoprophilous lichens that prefer such habitats include *Lecanora straminea, Caloplaca verruculifera, Physcia caesia* and *Xanthoria candelaria*, all present on the shores of Gwaii Haanas wherever the conditions are suitable.

The relative position of the marine and maritime species in Gwaii Haanas agree closely with observations made by others, in so far as there are species in common, e.g., *Verrucaria mucosa, V. striatula, Pyrenocollema halodytes* occur in the upper edges of the intertidal zone; *V. maura* appears higher and has a broad distribution*; Xanthoria candelaria*, *Physcia caesia* and *Caloplaca verruculifera* are associated with bird rocks; etc. (Eliasson 1965; Ryan 1988b; Sheard and Ferry 1967; Sheard 1968; Fletcher 1973a; Fletcher 1973b).

The west coast endemics, and especially the maritime lichens closely restricted to Haida Gwaii, comprise 17 of the 67 species listed in the Appendix. It is useful to examine these species to see what their ecological and taxonomic equivalents would be elsewhere in the world. We will begin with ecological relationships.

Caloplaca litoricola, a Haida Gwaii specialty, is in the Supralittoral *Caloplaca* zone as one would expect, but, since it is grey rather than yellow, it does not help to create an orange zone as other species of *Caloplaca* do in Europe or even eastern North America. On the other hand, the Pacific Northwest endemics *C. rosei* and *C. inconspecta,* and especially *Caloplaca flavogranulosa,* are the ecological equivalents of the similar European *C. marina* (also in western North America from California to Vancouver Island, but not reaching Haida Gwaii; Arup 1992), which is part of the "orange zone" of European shores. Instead of the fruticose cyanophilic lichen, *Lichina pygmaea*, common in the British Isles (and rare on the American east coast), we have *Spilonema revertens*, a microfruticose cyanophilic lichen in Gwaii Haanas, although it tends to be higher in the transects than *Lichina* would appear. Instead of species like the orange foliose lichen, *Xanthoria parietina* (common in both Europe and along the east coast of North America) in the Middle to Upper Supralittoral Zone, Haida Gwaii has the white crustose lichen *Coccotrema maritimum,* resulting in a conspicuous white zone replacing the orange zone seen in Europe. We have no ecological equivalent for their maritime saxicolous fruticose lichen, *Ramalina siliquosa*, but instead of *Fuscidea cyathoides*, Haida Gwaii has the narrowly endemic *F. thomsonii* in the Terrestrial zone (Brodo and Wirth 1998).

The distribution of geographically or ecologically separated, closely related taxa (vicariants) with respect to these endemics or near-endemics is especially interesting. The categories of relationships and the taxa involved are summarized below, in most cases, with references to discussions already published.

High Mountain connections

The following species either have close relatives in the arctic-alpine flora, or have populations/subspecies that are found only on maritime and alpine rocks, not in between.

Caloplaca litoricola: C. exsecuta (Nyl.) Dalla Torre & Sarnth. (Brodo 1984)

Ochrolechia subplicans: subsp. *hultenii* is on shoreline rocks; subsp. *subplicans* grows in the alpine zone from Haida Gwaii to Alaska (Brodo 1988).

Porpidia carlottiana: populations on Haida Gwaii either on shore or in mountains; close to *P. glaucophaea* (Körber) Hertel & Knoph in Hertel, an oceanic species (Gowan 1989).

Southern Hemisphere connections

These species are closely related to species common in the southern hemisphere, either in South America or Australasia.

Coccotrema maritimum: *C. cucurbitula* common on trees in Chile, etc. as well as in other parts of the Pacific Basin, e.g., Japan (Brodo 1973)

Collema fecundum: *C. novozelandicum* Degel., on calcareous non-maritime and maritime rocks and soil, South Island, New Zealand (Degelius 1974, 1979)

Verrucaria epimaura: *V. durietzii* I. M. Lamb, maritime lichen from the Aukland Islands (Brodo and Santesson 1997)

Kohlmeyera complicatula: the same or related species are on maritime rocks in western South America. (Brodo 1976)

Related to widespread maritime species

These species are most closely related to other maritime lichens.

Lecanora species number 1*: L. actophila, L. helicopsis* This undescribed *Lecanora* with a thick, white, xanthone-containing thallus will be discussed in a pub-

lication in preparation. It is clearly related to other species in the *L. dispersa* aggregate such as those listed above.

L. poliophaea (undescribed subspecies): subsp. *poliophaea.* The Haida Gwaii populations of *L. poliophaea* differ in some respects from European populations and are probably deserve taxonomic recognition. This will be discussed in the publication in preparation mentioned above.

Verrucaria. schofieldii: V. erichsenii, a widespread supralittoral species (Brodo and Santesson 1997).

Related to widespread non-maritime species

The following species have their closest relatives as Temperate or Boreal, non-maritime lichens.

Fuscidea thomsonii: *F. intercincta* (Nyl.) Poelt, *F. atlantica* (H. Magn) P. James & Poelt, both are European species found in regions with an oceanic climate (Brodo and Wirth 1998; Oberhollenzer and Wirth 1984).

Fuscopannaria maritima: *F. thiersii* P. M. Jørg., a Pacific Northwest species on iron-rich moist rocks (Jørgensen 2000); and *F. leucostictoides* Ohlsson, a western American corticolous species (Jørgensen 1978).

Porina pacifica: *Porina chlorotica* (Ach.) Müll. Arg., widespread northern species on shaded rock faces (Brodo 2004).

Rhizocarpon maritimum ined: *R. cinereovirens* is a Temperate species on shaded and exposed rocks, B. C., Black Hills, Long Island, N.Y. (The species, which will be described in a forthcoming paper, is closely related to *R. cinereovirens* (Fryday 2002: 463).

These phytogeographic relationships of the endemic or near-endemic maritime lichens of Haida Gwaii and their vicariant taxa suggest survival in the area during the Pleistocene glaciations. Relationships with montane species may indicate, as has been suggested (Clague 1989; Heusser 1989), that during the several glacial advances of the Pleistocene, some coastal areas and the highest mountain peaks of Haida Gwaii remained exposed. They would, therefore, have been available for colonization by lichens. It is possible that species that evolved at sea level from montane ancestors were highly restricted to coastal rocks and never were able to reinvade the intervening elevations although the highly exposed and harsh seacoast environment has much in common with alpine habitats and often shares the same or related species. It is probably significant that the closest relative of *Coccotrema maritimum*, a rock-dwelling species, is *C. cucubitula*, primarily a corticolous species throughout its range. A glacial relic would, of course, have to survive on non-arboreal substrates. Schofield (1989) notes that all the Haida Gwaii endemics among the bryoflora occur on rock or soil.

Many organisms are distributed around the Pacific Rim, or are disjunct from regions thousands of kilometres away. Plants and animals showing these patterns usually are related at the genus level or above, but these relationships show up at the species level in lichens and sometimes bryophytes (Schofield 1989). The fact that the land mass of Haida Gwaii represents a crustal plate fragment (terrane) that originated off the coast of Peru and and started its northward migration approximately 230 million years ago (Sutherland-Brown and Yorath 1989) provides a possible way for the species to have been transported (assuming the species had evolved by that time), although long distance dispersal is another means. Similar patterns are known from bryophytes; e.g., the moss *Polytrichadelphus lyellii* Mitt, which is known from British Columbia to California. The other 20 species of the genus are from South America, New Zealand and Australia (Persson, H. 1968. The possible migration routes of the species with southern hemisphere affinities are discussed by Brodo (1973).

Maritime lichens on Haida Gwaii that are disjunct with western Europe or even eastern North America probably reveal ancient, probably Tertiary, distribution patterns that were at first continuous but became dissected by climatic and geological events over the past 10-20 million years leaving the Haida Gwaii populations clinging to their outposts in microclimatically suitable habitats. Equivalent patterns among the mosses are common (Schofield 1984).

Conclusions

Rock-dwelling marine lichens of Gwaii Haanas are distributed in zones much as they are elsewhere in the world, although some species found abundantly only in Haida Gwaii create a unique appearance of these zones, such as the white *Coccotrema* zone, as compared with other regions. The unusually large percentage of endemic, near-endemic or disjunct species suggests that at least the headland rocks along the west coast were refugia during the last glacial maximum.

Acknowledgments

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Appendix: Lichens of Haida Gwaii Found on Maritime Rocks

Note: Many of the lichens listed below are non-maritime lichens that, on occasion, are found growing in the maritime zone thereby demonstrating a tolerance for salt spray. Species not found in Gwaii Haanas National Park Reserve are marked with an asterisk (*). Those new to British Columbia are in boldface. Voucher specimens of all these records can be found in the Canadian Museum of Nature (CANL).

Adelolecia koalensis (Nyl.) Hertel & Rambold (Syn. *Lecidea conferenda* Nyl.) This was first reported for British Columbia in Brodo (1995).
**Amandinea coniops* (Wahlenb. in Ach.) M. Choisy ex Scheid. & H. Mayrh.
Arthonia phaeobaea (Norman) Norman
Aspicilia caesiocinerea (Nyl. ex Malbr.) Arn.
**Aspicilia supertegens* Arn. This is not normally a maritime species. The single voucher specimen requires further study.
**Bacidina inundata* (Fr.) Vězda. This species was also found in streams in Haida Gwaii.
**Caloplaca chlorina* (Flotow) H. Olivier. The voucher specimen was verified by both T. Tønsberg and C. M. Wetmore.
Caloplaca citrina (Hoffm.) Th. Fr.
Caloplaca flavogranulosa Arup
**Caloplaca inconspecta* Arup
Caloplaca litoricola Brodo
Caloplaca rosei Hasse
Caloplaca verruculifera (Vainio) Zahlbr.
**Catillaria chalybeia* (Borrer) Massal.
**Cliostomum griffithii* (Sm.) Coppins
Coccotrema maritimum Brodo
Collema fecundum Degel.
**Ephebe lanata* (L.) Vainio
**Fuscidea mollis* (Wahlenb.) V. Wirth & Vězda. The voucher specimen is not typical of the species, so this record is questionable.
Fuscidea thomsonii Brodo & V. Wirth
Fuscopannaria maritima (P. M. Jørg.) P. M. Jørg.
Gyalecta jenensis (Batsch) Zahlbr.
Herteliana alaskensis (Nyl.) Zahlbr.
**Kohlmeyera complicatula* (Nyl.) Schatz
Lecanora muralis (Schreber) Rabenh.
**Lecanora poliophaea* (Wahlenb.in Ach.) Ach. s. lat.
Lecanora straminea Wahlenb. ex Ach.
**Lecanora tenera* (Nyl.) Cromb.
Lecanora sp. number 1. This is a xanthone-containing, maritime, saxicolous member of the *Lecanora dispersa* group and almost certainly is undescribed.
Lecanora sp. number 5. This lichen is similar in many respects with *L. contractula* Nyl.
**Lecidella scabra* (Taylor) Hertel & Leuckert
Lecidella stigmatea (Ach.) Hertel & Leuckert f. stigmatea
Ochrolechia subplicans (Nyl.) Brodo subsp. *hultenii* (Erichs.) Brodo
Opegrapha gyrocarpa Flotow
Opegrapha sp. This is a sorediate species containing roccellic acid, with 3-septate spores and lirelliform ascomata unlike those of *O. gyrocarpa*. It may be undescribed.
Parmelia saxatilis (L.) Ach.
Physcia caesia (Hoffm.) Fürnr.
Placopsis lambii Hertel & Wirth. There is a single record of *P. gelida* (L.) Lindsay s. str. on a rock in a tidal marsh, but otherwise the species is only known on Haida Gwaii from inland localities, usually on roadsides and fresh rock exposures.
**Polychidium muscicola* (Sw.) S. F. Gray
Porina pacifica Brodo. This species, which superficially resembles *P. chlorotica* (Ach.) Müll. Arg., was only recently described (Brodo 2004)
Porpidia carlottiana Gowan
Porpidia contraponenda (Arnold) Knoph & Hertel
Porpidia speirea (Ach.) Kremp.
Porpidia thomsonii Gowan
**Punctelia stictica* (Duby) Krog
Pyrenocollema halodytes (Nyl.) R. C. Harris s. lat. We have included specimens with sunken perithecia as well as those with sessile perithecia under this name if the perithecia were under 0.3 mm in diameter. The much larger *P. sublitorale* (Leighton) R. C. Harris ex Fletcher in Coppins, P. James & D. Hawksw. has not yet been found in Haida Gwaii.
Rhizocarpon geminatum Körber
Rhizocarpon "haidensis" Brodo, ined. This species is closely related to *R. cinereovirens* (Müll. Arg.) Vainio (Fryday 2002). Its description is being prepared for publication.
**Rhizocarpon hensseniae* Brodo
Rhizocarpon hochstetteri (Körber) Vainio s. str. A detailed discussion of this species is provided by Fryday (2002).
**Rinodina gennarii* Bagl.
Spilonema revertens Nyl.
**Tephromela atra* (Hudson) Hafellner in Kalb
**Tylothallia biformigera* P. James & R. Kilias in R. Kilias
Verrucaria amphibia Clemente
Verrucaria degelii R. Sant.
Verrucaria epimaura Brodo
Verrucaria erichsenii Zsch.
**Verrucaria halizoa* Leighton
Verrucaria maura Wahlenb. in Ach.
Verrucaria mucosa Wahlenb. in Ach.
Verrucaria sandstedei de Lesd. This species, like *V. striatula* listed below, was reported from coastal rocks in Fildago Island, Washington, by Ryan (1988a, b).
Verrucaria schofieldii Brodo
**Verrucaria silicicola* Fink
Verrucaria striatula Wahlenb. See comment under *V. sandstedei*.
Verrucaria sp. number 5 (dry rock at edge of beach)
Xanthoria candelaria (L.) Th. Fr.

Predaceous Water Beetles (Coleoptera: Adephaga: Dytiscidae, Gyrinidae) Collected Along the Horton and Thelon Rivers in the Arctic Central Barrens of Canada

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Predaceous water beetles were collected during expeditions along two northern Canadian rivers during 2000 and 2002. Twelve species of Dytiscidae (including 11 named species and one additional genus identified from a larva) and one species of Gyrinidae are recorded from 20 sites along the Horton and Thelon rivers in the Central Barrens area of the Canadian Arctic. These records represent an extension of the distributions of four species to the northeast in the Northwest Territories (NWT), and two species to the northwest in Nunavut (NU). *Oreodytes sanmarkii* is reported for NWT and for the mainland of NU for the first time. *Ilybius erichsoni, Hydroporus geniculatus,* and *Gyrinus opacus* are reported for NU for the first time. Five species were recorded for the first time from the Southern Arctic ecozone, and one from the Taiga Shield ecozone. The majority of specimens were collected in habitats that were consistent with those previously known for each species.

Key Words: Insecta, Coleoptera, Adephaga, Dytiscidae, Gyrinidae, predaceous water beetles, faunistics, river, Northwest Territories, Nunavut, Arctic Central Barrens.

The Central Barrens area of the Canadian Arctic is a vast and very sparsely populated area dominated by arctic tundra, scattered clumps of taiga vegetation, large lakes, and rivers. The inaccessibility of the region has meant that the area has been poorly collected for all insect groups (Currie et al. 2000), including predaceous water beetles. Only three surveys have been conducted on aquatic Adephaga in the Yukon, Alaska, and the eastern Canadian Arctic (Alarie and Maire 1991; Larson 1991, 1997), though data on this group of Coleoptera in arctic and subarctic regions can also be found in Larson and Roughley (1991), Roughley (1991), Anderson (1997), and Larson et al. (2000). Recently a series of expeditions were mounted to explore the aquatic insect fauna along large river systems on the treeless barrens of the mainland Canadian Arctic zone (Currie et al. 2000, 2002). The objective of this paper is to report on the predaceous water beetles collected from habitats in and near the Horton River Northwest Territories (NWT) and the Thelon River, NWT and Nunavut (NU), and present faunistic and habitat data from the collections.

Methods

Two expeditions were made by DJG and colleagues from various institutions to northern Canadian rivers during 2000 and 2002 (Figure 1). Expedition members flew in to upstream sections of the Horton and Thelon rivers in NWT and travelled downriver by canoe, stopping frequently to sample habitats along the linear corridor of each river. Aquatic sampling was carried out using a D-frame kick net with a 200 µm mesh. In flowing water habitats, the net was placed into the stream and the substrate disturbed by kicking or by moving rocks by hand, and the dislodged insects were carried into the net by the current. In areas with little or no flow, the substrate was disturbed as above, and then the net was drawn through the water by hand to catch any dislodged insects. Insects were sorted alive from the substrate materials on site, and preserved in 80% ethanol. Predaceous water beetles were not specifically targeted in the study, but those that were collected (61 adults and 6 larvae) were examined by HVS. Collection records were compared to the maps and distribution table in Larson et al. (2000) to determine whether any of them represented range extensions among the provinces and ecozones. The document *A National Ecological Framework for Canada* (Ecological Stratification Working Group 1995) was consulted for the classification of Canada's ecological regions. Collecting Permits were obtained from the Aurora Research Institute (Inuvik, NWT) and the Nunavut Research Institute (Iqaluit, NU) to carry out the research. Voucher specimens have been deposited in the collections of the Wallace Museum (University of Manitoba) and the Royal Ontario Museum, and in the private collection of D. J. G.

Study Site and Sampling Regime

The Horton River begins west of Horton Lake, which is located north of Great Bear Lake in the Northwest Terriories of Canada (Figure 1). The river, which has

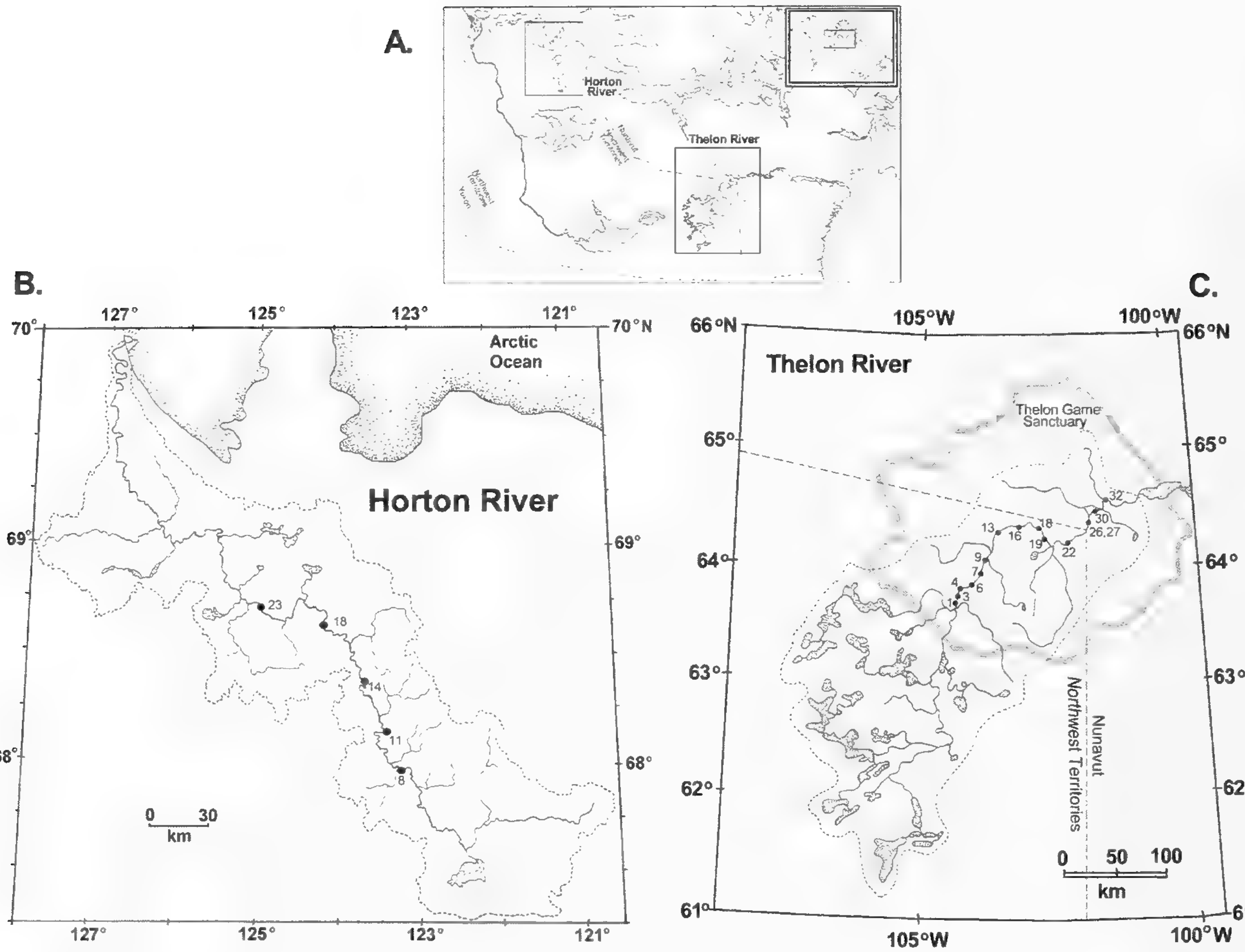

FIGURE 1. Location of study area (A), including the Horton River (B) and Thelon River (C) showing sample sites. The fine dashed line indicates the watershed boundary upstream of the lowest sampled site for both watersheds. The grey border on the Thelon Watershed map indicates the boundaries of the Thelon Game Sanctuary. Site co-ordinates are given in Table 1.

a drainage basin area of approximately 26 680 km^2 and a total length of ≈ 800 km, runs entirely in the Southern Arctic Ecozone. Expedition members collected over a 700 km stretch of the river from Horton Lake to the Arctic Ocean. The river flows over limestone-dominated substrates in its upper reaches, where it is characterized by relatively high pH (>8.0) and specific conductance (>150 µS/cm). In its lower reaches, the river flows through the Smoking Hills, a region containing lignite and magnesium deposits which spontaneously ignite when exposed to air (for example, during bank slumping during summer). These result in "smoke holes" as smoke pours from places where the coal is burning underground, and the water draining these sites is profoundly affected by the geology. Tributaries and ponds in this region were highly acidic (some with pH values < 2.5), and acid runoff in this area resulted in a decline in river pH to approximately neutral values. The river is clear and swift-flowing for most of its length, but becomes muddy and meandering in its lower portion. Sampling was carried out in 37 sites on or near the river between 17 July and 8 August 2000. Predaceous water beetles were collected from 5 of the 37 sites along the river, corresponding to sampling sites 8, 11, 14, 18, and 23 of the larger Horton River survey; all were located in the middle section, which was clear and swift-moving (Figures 1b, 2; see Table 1 for descriptions of each site).

The Thelon River begins near Lynx Lake, to the east of Great Slave Lake (Figure 1). The river flows ≈ 900 km from Lynx Lake to Baker Lake (which exits via Chesterfield Inlet to northern Hudson Bay to the east) and drains a total area of ≈ 240 000 km^2. The upper portions of the Thelon River are in the Taiga Shield ecozone, then the river flows into the Southern Arctic ecozone. Expedition members flew into the junction of the Hanbury and Thelon rivers, and collected along a 300 km stretch of the Thelon River located within the bounds of the Thelon Game Sanctuary (Figure 1c). The part of the river covered in this survey (i.e., upstream of Beverly Lake, NU) drains an area of 71 470 km^2. The river corridor upstream of the study area consists of large numbers of lakes, waterfalls, and rapids, but in the study area itself, the river meanders over an ancient glacial lake bottom. At this point, the river is wide and slow moving and dominated by sandy or sand/silt-embedded cobble substrates. Surrounding relief is very low except in a few spots,

FIGURE 2. Study sites along the Horton River where predaceous water beetles were collected, July/August 2000 (compare to Figure 1B for site locations).

where low hills, boulders, and more rapid flow can be found. Most of the river flows through open tundra, but a small stretch in the upper third of the study area (≈ 65 km) is located in a remnant spruce and larch forest known as the "Thelon Oasis". The pH and specific conductance values were quite low, especially in comparison with the Horton River, with pH values generally around 6.0, and specific conductance values ≈ 10 µS/cm for main river sites. pH and conductivity values for tributaries and tundra pools were more variable, however. Sampling was carried out at 34 sites on or near the river between between 29 June and 11 July 2002. Predaceous water beetles were collected from 15 of the 34 sites, representing a combination of river and pool sites corresponding to sites 1, 3, 4, 6, 7, 9, 13, 16, 18, 19, 22, 26, 27, 30, and 32 of the larger Thelon River survey (Figures 1c, 3; see Table 1 for descriptions of each site).

Results and Discussion

Oreodytes laevis (Kirby) and *O. sanmarkii* (Sahlberg) were the two most common species found in our northern rivers survey, and were also the only species found in both rivers (Table 1). *Oreodytes laevis* accounted for 26 of the 61 adults collected (> 40%) and was found in eight of the 20 sites where water beetles were found.

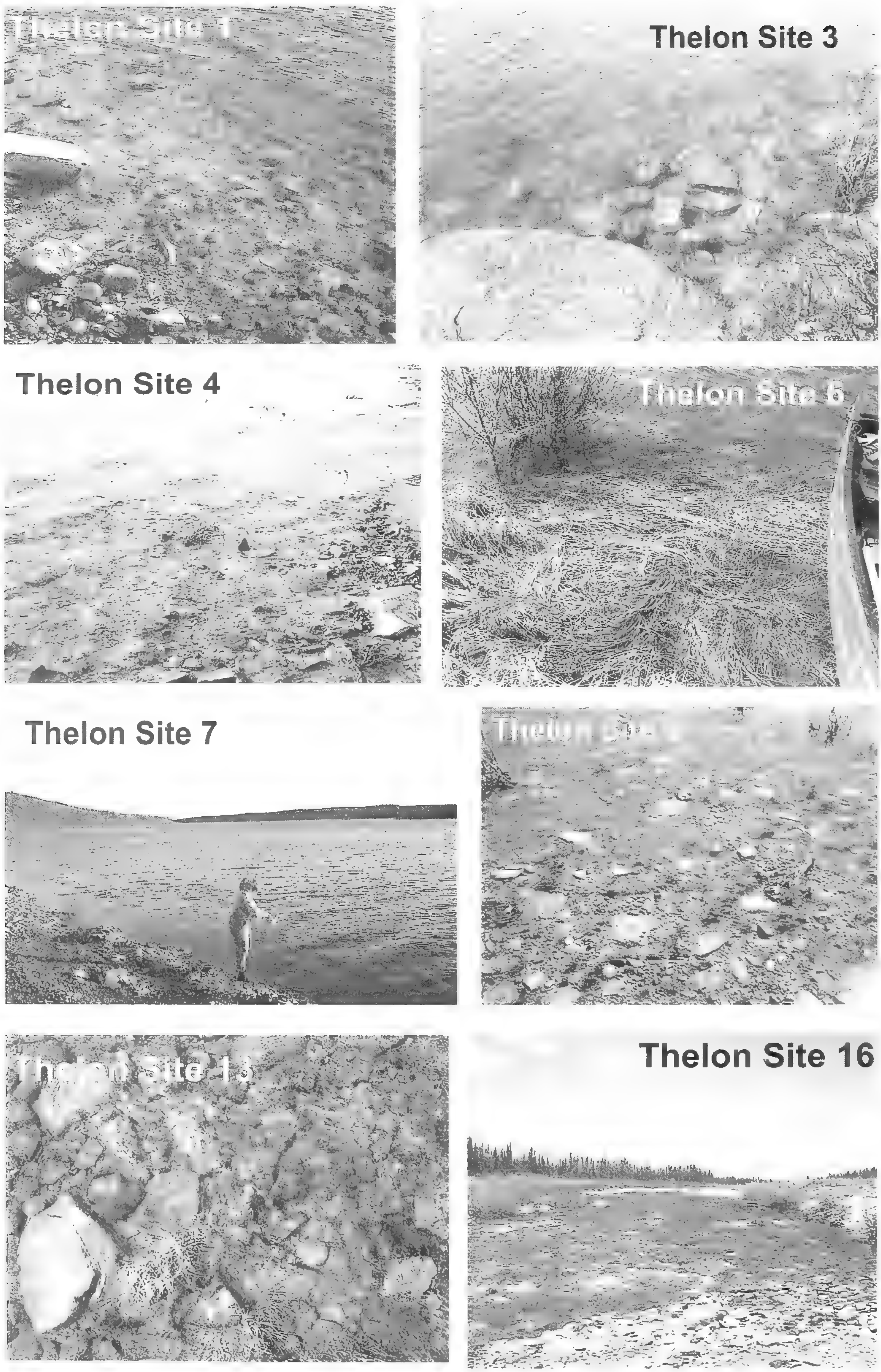

FIGURE 3a. Study sites along the upper reaches of the Thelon River where predaceous water beetles were collected, July/August 2000 (compare to Figure 1C for site locations).

FIGURE 3b. Study sites along the lower reaches of the Thelon River where predaceous water beetles were collected, July/August 2000 (compare to Figure 1c for site locations).

TABLE 1. Distribution and abundance of predaceous water beetles collected along the Horton and Thelon Rivers. All species were collected in the main branch of the rivers except where specifically indicated. All species were in the family Dytiscidae except *Gyrinis opacus* which was in the family Gyrinidae.

Site	Coordinates / Date	Site Details	Species	Specimens
Horton River, NWT				
8	67°59'24.5"N 123°13'55.5"W 20 July 2000	cobble dominated riffle and shore section, where river slowed and flowed through a broad valley; pH: 8.3; conductivity: 150 µS/cm; temp.: 15°C	*Oreodytes laevis* (Kirby) *Oreodytes sanmarkii* Sahlberg	1 ♀ 1 ♂
11	68°09'29"N 123°22'44.9"W 22 July 2000	slow, weedy shoreline area along the main channel of the river (fill in from logbook); pH: 8.2; conductivity: 180 µS/cm; temp.: 10.5°C	*Oreodytes sanmarkii*	1 ♂
14	68°23'31.5"N 123°38'03.4"W 23 July 2000	backwater zone and a riffle, from a portion of the river in a narrow valley surrounded by high limestone cliffs; pH: 8.2; conductivity:180 µS/cm; temp.: 12°C	*Oreodytes laevis*	2 ♂♂
18	68°39'3.18"N 124°08'53.0"W 25 July 2000	the river is a series of very shallow flats and riffles; temp.: 12°C	*Oreodytes sanmarkii*	1 ♂
23	68°44'19.9"N 124°59'0.8"W 28 July 2000	canyon/white-water area of the river, deep bedrock pools and fast riffles; at camp spot no obvious riffles though water moving very fast; sampled from shore; temp.: 17°C	*Oreodytes sanmarkii*	1 ♂
Thelon River, NWT				
1	63°38'04.8"N 104°32'18.6"W 29 June 2002	relatively slow and wave washed section near shore, in silt/sand embedded cobble; pH: 6.2; conductivity: 10 µS/cm; temp.: 11°C	*Oreodytes sanmarkii*	2 ♂♂
3	63°42'04.4"N 104°25'26.6"W 30 June 2002	rocky shore with fairly strong current, and in backwater pools behind large boulders; pH: 6.2; conductivity: 10 µS/cm; temp.: 11°C	*Oreodytes laevis* *Oreodytes sanmarkii*	2 ♂♂ 3 ♀♀ 1 ♂ 2 ♀♀
4	63°48'22"N 104°18'21.1"W 30 June 2002	slow section near shore, with cobble substrate embedded in sand and silt; pH: 6.2; conductivity: 10 µS/cm; temp.: 10.5°C	*Oreodytes laevis*	5 ♂♂ 1 ♀
6	63°49'58.4"N 104°06'20.9"W 1 July 2002	submerged grasses in slow current near shore, 10 m upstream of a tributary entering from the south; pH: 6.2; conductivity: 40 µS/cm; temp.: 14°C	*Oreodytes laevis* *Hygrotus novemlineatus* (Stephens)	1 ♂ 1 ♀
7	63°55'02.7"N 103°56'59.5"W 1 July 2002	cobble and silt substrate near shore where main river narrowed and became swift flowing, even near shore; pH: 6.2; conductivity: 10 µS/cm; temp.: 11°C	*Oreodytes laevis* *Stictotarsus griseostriatus* (DeGeer)	3 ♂♂ 4 ♀♀ 1 ♂
9	64°02'13.2"N 103°51'41.8"W 2 July 2002	at Hornby Point; well embedded cobble in fast, shallow riffle near shore; pH: 6.1; conductivity: 10 µS/cm; temp.: 12°C	*Oreodytes laevis*	1 ♂, 1 ♀
13	64°17'01.8"N 103°33'22.4"W 3 July 2002	cobble substrate in fast water in main channel, plus slower water near shore; pH: 6.3; conductivity: 30 µS/cm; temp.: 13°C	*Stictotarsus griseostriatus*	1 ♀
16	64°19'18.6"N 103°19'15.7"W 4 July 2002	unnamed tributary entering Thelon River from forest to the north; riffle with large clean cobble substrate; pH: 7.6; conductivity: 40 µS/cm; temp.: 16°C	*Oreodytes sanmarkii*	1 ♂
18	64°17'56.2"N 102°43'20.6"W 5 July 2002	river wide and lake-like; wave-washed area, in cobble substrate well embedded in sand; pH: 6.3; conductivity: 10 µS/cm; temp.: 13.5°C	*Oreodytes laevis*	1 ♂, 1 ♀

TABLE 1 *(continued)*. Distribution and abundance of predaceous water beetles collected along the Horton and Thelon Rivers. All species were collected in the main branch of the rivers except where specifically indicated. All species were in the family Dytiscidae except *Gyrinis opacus* which was in the family Gyrinidae.

Site	Coordinates / Date	Site Details	Species	Specimens
19	64°10'46.1"N 102°36'58.1"W 6 July 2002	small brown-water tundra pools above the river on north, pools draining to each other and seeping to the river; overhanging vegetation, undercut banks, stony bottom; pH: 6.0; conductivity: 20 µS/cm; temp.: 14°C	*Hydroporus appalachius* Sherman *Agabus confines* (Gyllenhal) *Ilybius erichsoni* (Gemminger and Harold)	2 ♂♂ 2 ♀♀ 4 ♀♀ 1 L3* 1 ♀
22	64°11'05.4"N 102°19'06.9"W 7 July 2002	unnamed tributary seep entering the river from the north and small brown-water tundra pools surrounded by willows, shorelines with sphagnum and grass; pH: 5.7; conductivity: 50 µS/cm; temp.: 9°C	*Agabus* sp.	2 L3*
Thelon River, NU				
26	64°19'13.2"N 101°50'11.1"W 8 July 2002	unnamed tributary entering the river from the north; cobble substrate in riffle area of the stream; pH: 6.5; conductivity: 10 µS/cm; temp.: 11°C	*Oreodytes sanmarkii*	1 ♀
27	64°19'13.2"N 101°50'11.1"W 8 July 2002	small brown-water tundra pond beside site 26; much submerged and decaying vegetation (grass); pH: 6.0; conductivity: 10 µS/cm; temp.: 15°C	*Hydroporus geniculatus* Thomson *Ilybius erichsoni*	1 ♂ 1 ♂ 2L3*
30	64°26'15"N 101°43'55.1"W 9 July 2002	large tundra pond on southern bank above the river, with overhanging willows and soft bottom substrates; pH: 6.0; conductivity: 10 µS/cm; temp.: 12°C	*Stictotarsus griseostriatus* *Agabus arcticus* (Paykull) *Rhantus* sp. *Gyrinus opacus* Sahlberg	1 ♂ 1 ♂ 6 ♀♀ 1 L2* 1 ♀
	64°32'25.2"N 101°24'48.9"W 10 July 2002	unnamed small tributary entering the river from the south - small pools and seeps between the pools; overhanging vegetation; pH: 6.2; conductivity: 20 µS/cm; temp.: 14°C	*Hydroporus morio* Aubé *Agabus thomsoni* (Sahlberg)	3 ♀♀ 1 ♂, 1 ♀

Note: * L3 – larva of third instar; L2 – larva of second instar.

Eleven specimens of *Oreodytes sanmarkii* were also found at eight sites. *Stictotarsus griseostriatus* (DeGeer) specimens were collected in three of the sites, but there was only a single specimen in each collection. The remaining species were all restricted to a single site each. Although several specimens of individual species were often found, for example, the sites with *Agabus confinis* (Gyllenhal) and *A. arcticus* (Paykull) (Table 1).

These collections are range extensions among the provinces and ecozones of Canada for most of the species collected, and represent a "filling in of gaps" in the distributions of many northern species. Because of logistic difficulties in sampling these interior regions of the arctic barrens, many previously reported species distributions have appeared disjunctive, or restricted to coastal areas (e.g., Larson et al. 2000). For example, the known ranges of *Hydroporus appalachius* Sherman, *Oreodytes laevis,* and *Agabus confinis* are extended to the northeast within the Northwest Territories, and those of *Agabus arcticus and A. thomsoni* Sahlberg are extended to the northwest within Nunavut. *Oreodytes laevis* and *Hydroporus appalachius* are widespread in the boreal low arctic zone of the Nearctic, so these records represent an extension into the Tundra zone. With respect to ecozone distribution, *O. laevis, H. appalachius,* and *A. confinis* are recorded for the first time from the Southern Arctic ecozone, and *A. confinis* is now known from all ecozones of Canada except the prairies. *Ilybius erichsonii* (Gemminger and Harold) is reported for the first time for Nunavut, and its known range is extended to the northeast within the Northwest Territories, and into the Southern Arctic Ecozone. *Ilybius erichsonii* has now been reported from all the ecozones of Canada. *Hydroporus geniculatus* Thomson is a Holarctic species which occurs in the boreal and alpine zones in northwestern North America. In Canada, it is distributed throughout most of British Columbia and western Alberta, and north into the Yukon Territory and Alaska (Larson et al. 2000), and is reported for the first time in this study in Nunavut and in the Southern Arctic ecozone. The present record is an extension of its known

distribution far to the northeast, and therefore the range for this species appears disjunctive. However, *H. geniculatus* belongs to the poorly studied *nigellus*-group, and revision of the group is needed to clarify its taxonomic position and distribution. We report the presence of *Oreodytes sanmarkii* in the Northwest Territories and in the Taiga Shield ecozone for the first time, and the collections along the Thelon River also represent the first record of the species on the Nunavut mainland. This Holarctic species was previously known in Canada from a few sites in northern Yukon and a site on Southampton Island (NU) (Larson et al. 2000). *Hygrotus novemlineatus* (Stephens), *Hydroporus morio* (Aubé), and *Stictotarsus griseostriatus* have been reported in the Canadian Barrens to the east and west of the sampled areas, but these collections indicate that their distributions are more continuous across the north than previous distribution maps might indicate. *Gyrinus opacus* (Gyrinidae) is reported for Nunavut for the first time, and collections on the Thelon River may represent the most northeasterly record for the species (Oygur and Wolfe 1991). However, this record is in need of confirmation since it is based on study of a single female specimen.

Most of the species were collected in habitats that matched those that were previously reported for each species (e.g., Larson et al. 2000). However, this study has produced some new and additional data on habitat distributions for several species. *Oreodytes laevis* and *O. sanmarkii* have been reported in rivers, streams, and along exposed shorelines of cold lakes with little or no submerged vegetation, and with mineral substrates. These two species dominated in these types of habitat along the Thelon and Horton rivers. According to Alarie and Maire (1991; as *H. hudsonicus*) and Larson et al. (2000), *Hygrotus novemlineatus* is circumpolar in the low arctic region and has been collected in Canada (near Churchill Manitoba, and in Quebec) in brackish splash pools (rock-pools) along the coast. However, in our survey it was collected among dense submerged grass in slow water current along the shore of the Thelon River. The species may have relatively wide habitat preferences, since Nilsson and Holmen (1995) reported it in Fennoscandia from similar habitats to the Thelon site, as well as from sandy oligotrophic lake margins and sparsely vegetated ponds. In the southern parts of its range, *Hydroporus appalachius* is usually found in habitats where there is some water movement, for example in streams, springs, and the margins of small lakes (Larson et al. 2000). In Labrador, the species was collected from a protected shoreline of a large lake (Larson et al. 2000), and it has been found in inland pools in the Quebec subarctic region (Alarie and Maire 1991). The habitat in the more northern parts of its range has not previously been described, and in this survey, it was found in small tundra pools that drained into each other before spilling into the Thelon River.

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Notes

Collapsing Burrow Causes Death of a Eurasian Beaver, *Castor fiber*

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Thomsen, Liat R., Fiona Sharpe, and Frank Rosell. 2004. Collapsing burrow causes death of a Eurasian Beaver, *Castor fiber*. Canadian Field-Naturalist 118(3): 434-435.

The death of a Eurasian Beaver *Castor fiber* caused by a collapsing burrow in southeast Norway is reported. Two days of heavy rainfall had presumably caused the burrow to collapse, suffocating the animal.

Key Words: Beaver, *Castor fiber*, collapsing burrow, southeast Norway.

Several causes of death have been reported for Eurasian Beavers (*Castor fiber*) (Rosell et al. 1996; Nolet et al. 1997), but to our knowledge this is the first report of a beaver killed due to a collapsing burrow. The beaver was an adult solitary male (21.5 kg and 5 years old; age was determined by examining annual cementum and dentine layers of the first molar (van Nostrand and Stephenson 1964)). His mate died two months earlier, probably due to old age (18 years old). The animal was one of several radio tagged beavers that were followed during a field study in spring and summer 2000 in Telemark County, southeast Norway (59°25'N, 09°03'E) (see Campbell 2000). On the evening of 14 July 2000 it was noted that the pulse interval of the radio signal had increased. The signal is inversely related to the body temperature of the animal (Alterra 1999), thus a higher pulse interval indicated that the beaver had died. The dead beaver was located in the main part of a partly collapsed burrow (assessed to be relatively new), which was excavated four days later in order to find and retrieve the carcass (Figure 1).

Beavers dig burrows where banks are sufficiently high (Wilsson 1971; Żurowski 1992). A burrow usually consists of a single living chamber, a water basin, and a tunnel with exit below the water level (Wilsson 1971). The beaver was lying in the chamber (1 m long and 70 cm wide) of the collapsed burrow, facing towards the exit. The chamber was situated 210 cm from the water's edge, 80 cm below the surface of the riverbank, and 60 cm above the current water level. Apparently the ceiling of the chamber had collapsed on top of the beaver causing the death of the animal, presumably by suffocation. There was loose sand along the flanks of and underneath the body of the dead beaver. The last 10 cm of the beaver's tail was bent downwards into the sand and the right hind foot was crouched as if the beaver had been attempting to dig with it. The beaver had no external injuries and seemed to be in good condition.

FIGURE 1. The dead solitary adult beaver located in the chamber of a partly collapsed burrow.

The burrow was dug in sandy soil. In the week prior to the discovery of the beaver there had been two days with heavy rainfall in the area with 30.8 mm and 24.6 mm of rain, respectively (data from the Norwegian Meteorological Institute).

We conclude that the combination of heavy rainfall and a sandy soil had caused the burrow to collapse, therefore causing the death of the beaver. How prevalent this cause of death is in beavers is unknown. However, we expect that more field studies using radio telemetry, in areas where beavers dig burrows, could clarify this issue.

Acknowledgments

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Frequency of Tail Breakage of the Northern Watersnake, *Nerodia sipedon sipedon*

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I noted the frequency of broken tails of Northern Watersnakes, *Nerodia sipedon sipedon*, in the Beaver Archipelago of Northeastern Lake Michigan. Overall, 10% (22 of 220) of captured snakes had broken tails. This value is similar to published values for closely related snakes but is smaller than those reported for another *Nerodia sipedon sipedon* population. Unlike some previously published studies, the frequency of injured tails was not greater for females or lesser for first-year snakes. The mechanism behind the injury frequency observed here and the reason for differences between this and other studies are unknown.

Key Words: Beaver Archipelago, *Nerodia sipedon sipedon*, Northern Watersnake, tail breakage, Michigan.

The frequency of tail injuries in a lizard or snake population was at one time considered to be a useful index of the predation pressure on that population because tail autotomy and breakage (Mendelson 1992) are thought to be important defense mechanisms (reviewed in Arnold 1988). More recently, theoretical and empirical tests of this hypothesis have led to the assertion that loss or injury of the tail may instead be related to predator inefficiency or alternative sources of mortality and that careful investigation must be undertaken to determine the mechanism behind observed injury frequencies (Schoener 1979; Medel et al. 1988). While such data must indeed be interpreted with caution, reporting the frequency of tail injury in study populations can be useful when combined with demographic data (Arnold 1988), for example in forming hypotheses regarding sex or size-based differences in anti-predator mechanisms (Fitch 2003).

Several researchers have reported the frequency of tail injuries in populations of snakes. Fitch (1999) found that the frequency of tail breakage increased with the age/size of individuals in a Kansas population of *Nerodia s. sipedon,* the Northern Watersnake. More specifically, the frequency of female tail breakage ranged from 21.2 to 44.5%, and the frequency of male tail breakage ranged from 6.5 to 25% in increasing body size categories. Willis et al. (1982) reported that female Eastern Garter Snakes (*Thamnophis sirtalis*) and Northern Ribbon Snakes (*Thamnophis sauritus*) had a higher incidence of tail loss than males (13% versus 6%, and 12% versus 7%, respectively) and that tail loss was more prevalent in larger size classes. However, neither trend was statistically significant in populations of Butler's Garter Snake (*Thamnophis butleri*). Fitch (2003) found that tail breakage was more common for female *T. sirtalis* (16.7%) than for males (10.3%) and more common for large snakes (13.7%) than for first-year snakes (2.42%). In general, females and larger snakes appear more likely to have broken tails.

I studied the frequency of broken tails of the Northern Watersnake in the Beaver Archipelago of northeastern Lake Michigan during the summers of 2000 and 2001. I captured snakes from Beaver Island (45°41.26'N, 85°30.34'W), Garden Island (45°48.28'N, 85°29.41'W), High Island (45°43.88'N, 85°39.54'W), and Hog Island (45°48.39'N, 85°22.15'W). Upon cap-

TABLE 1. Chi-square contingency table for comparison of the frequency of tail breakage among male, female, and first-year *Nerodia sipedon sipedon* in the Beaver Archipelago of Lake Michigan. The calculated χ^2 was 0.23 (critical $\chi^2 = 5.99$, df =2).

Class	Number of injured snakes	Number of uninjured snakes	Total	% Injured
Male	7	55	62	11.3
Female	13	120	133	9.8
First-year	2	23	25	8.0
Totals	22	198	220	10.0

ture, I brought snakes to the laboratory where I then measured snout-vent length (SVL) and noted the tail condition and sex of each individual. I released all snakes at the point of capture as soon as possible after processing. I pooled snakes from all islands and calculated the overall percentage of snakes with tail breaks. I also compared the frequency of broken tails among males, females, and unsexed first-year snakes, and among three capture locations (Beaver Island Lake Michigan shoreline, Beaver Island interior lake, and Garden Island Lake Michigan shoreline) within sexes using Chi-square contingency table analysis. I hypothesized that females would have a higher frequency of tail breakage than males and that first-year snakes would have a lower frequency of tail breakage than both males and females.

Two hundred and twenty snakes were captured from the four islands. Beaver Island produced 153 snakes, Garden Island 55, High Island 1, and Hog Island 11 snakes. Captured snakes ranged in size from 149 to 860 mm SVL with a mean of 478.2 mm and a standard deviation of 164 mm. In all, 10% (22) of the snakes had broken tails. There was no statistically significant difference in the frequency of tail breakage among males, females, and first-year snakes ($\chi^2 = 0.23$, critical $\chi^2 = 5.99$, df = 2; Table 1). Within males, there was no statistically significant difference in the frequency of tail breakage among capture sites ($\chi^2 = 0.33$, critical $\chi^2 = 5.99$, df =2; Table 2). However, females captured on the Lake Michigan shoreline of Garden Island had a higher frequency of tail breakage than those captured elsewhere ($\chi^2 = 8.9$, critical $\chi^2 = 5.99$, df =2; Table 3).

My data do not closely match those of any previous studies. The overall frequency of tail breakage is similar to that reported by Willis et al. (1982). However, unlike the populations of *N. s. sipedon* and *T. sirtalis* studied by Fitch (1999; 2003), and the populations of *T. sirtalis* and *T. sauritus* studied by Willis et al. (1982), the frequency of broken tails is not greater for females in the Beaver Archipelago overall (although it is greater if only Garden Island is considered). Furthermore, first-year snakes in the Beaver Archipelago do not appear to have a lower frequency of tail breakage than larger snakes. The *T. butleri* populations of Willis et al. (1982) appear to be similar to my snakes in the lack of common patterns of tail breakage. The sample size (287) for *T. butleri* in that study is similar to my own, while the sample sizes of the *T. sirtalis*, *T. sauritus* and *N. s. sipedon* studies are considerably larger. This suggests that the ability to detect patterns in the frequency of tail injuries in snake populations may be dependent upon sample size.

TABLE 2. Chi-square contingency table for comparison of the frequency of tail breakage of male *Nerodia sipedon sipedon* among capture sites in the Beaver Archipelago of Lake Michigan. The calculated χ^2 was 0.33 (critical $\chi^2 = 5.99$, df =2).

Capture site	Number of injured snakes	Number of uninjured snakes	Total	% Injured
Beaver Island Lake Michigan shoreline	2	15	17	11.8
Beaver Island interior lakes	2	20	22	9.1
Garden Island Lake Michigan shoreline	3	18	21	14.3
Totals	7	53	60	11.7

TABLE 3. Chi-square contingency table for comparison of the frequency of tail breakage of female *Nerodia sipedon sipedon* among capture sites in the Beaver Archipelago of Lake Michigan. The calculated χ^2 was 8.9 (critical $\chi^2 = 5.99$, df =2).

Capture site	Number of injured snakes	Number of uninjured snakes	Total	% Injured
Beaver Island Lake Michigan shoreline	4	60	64	6.2
Beaver Island interior lakes	2	34	36	5.5
Garden Island Lake Michigan shoreline	7	21	28	25.0
Totals	13	115	128	10.1

Fitch (2003) suggested that the frequency of tail breakage should be expected to vary among different study sites based on the presence of predators and availability of escape cover. Such factors may explain the differences in overall frequency of tail breakage between this and other studies and between islands in the Beaver Archipelago within females. Fitch (1999) also suggested that *N. s. sipedon* individuals with greater mass are more likely to have broken tails because they whirl repeatedly in an attempt to escape when grasped by a predator. Greater mass makes tail breakage more likely when this whirling motion is employed. The smaller mass of first-year snakes, the smaller mass of male *N. s. sipedon* in comparison to females of the same age (Fitch 1999), and the fact that broken tails may potentially damage the hemipenes of males all suggest that these groups should have lower frequencies of tail breakage than large snakes and females, respectively, regardless of locality. These patterns were not clear in this study or in the populations of *T. butleri* studied by Willis et al. (1982).

Sample size may be the critical factor in the discrepancy between studies. The two studies that did not show common patterns in tail breakage had relatively small sample sizes. A large sample size may be necessary for two reasons: (1) the patterns are real but the categorical nature of the data (break or no break) requires that large samples be collected for a pattern to be detectable, or (2) the patterns are not real but stem from the fact that any difference, no matter how small, can be statistically significant if the sample size is large enough (Johnson 1999). The general similarity of patterns of tail breakage across studies with large sample sizes suggests that the first reason may be the case. However, discrepancies among studies underscore the need for more research in this area. Researchers should continue to record and report the frequency of tail breakage in populations of lizards and snakes, but more carefully designed studies that attempt to determine the direct causes and consequences of tail breakage are needed (Medel et al. 1988). Until such studies are carried out, the meaning and utility of tail breakage data will remain speculative.

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The Heather Vole, Genus *Phenacomys,* in Alaska

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MacDonald, S. O., Amy M. Runck, and Joseph A. Cook. 2004, The heather vole genus *Phenacomys*, in Alaska. Canadian Field-Naturalist 118(3): 438-440.

Four specimens of heather vole (genus *Phenacomys*) collected in the coastal mountains of Southeast Alaska document the first Recent records of this vole in Alaska. Alternative hypotheses on the relationship of these newly-discovered populations to extant and historical populations are outlined, and additional studies proposed.

Key Words: Heather vole, *Phenacomys* sp., Southeast Alaska.

Since publication of a synopsis of the land mammal fauna of Southeast Alaska (MacDonald and Cook 1996), new field and laboratory studies of the mammals of this region have resulted in new perspectives on the zoogeography of the North Pacific Coast (Conroy et al. 1999; Cook and MacDonald 2001; Cook et al. 2001). In our 1996 publication, we speculated that several mammal species found on the eastern side of the coastal mountains in Canada may occur along the Alaska coast. One species, the heather vole (*Phenacomys intermedius*), had previously been recorded within 2 km of the southern Alaska border in the subalpine near Salmon Glacier in British Columbia (approximately 56.17° N, 130.03° W), and Nagorsen and Jones (1981) reported its occurrence in the Chilkat Pass north of Haines and Southeast Alaska. Subsequent trapping efforts in Alaskan mountains near Salmon Glacier and elsewhere along the mainland coast resulted in the capture of four specimens of this vole (Table 1) from two widely separate localities (Figure 1). These specimens, deposited at the University of Alaska Museum (UAM), constitute the first documented records of extant populations of heather vole in Alaska.

On 11 August 1996, we captured a single heather vole (UAM 42371) above timberline in the glacially-isolated Chilkat Range at the northern end of Southeast Alaska near Excursion Inlet, Glacier Bay National Park (58.41° N, 135.43° W; elevation approximately 900 m). Also recorded in this alpine area were *Sorex monticolus* and melanistic *Marmota caligata*.

In 1999, three heather voles were collected from the far southern end of mainland Southeast Alaska, approximately 400 km south of the 1996 Glacier Bay record. On 23 September 1999, two male (UAM 64239, UAM 64240) and one female (UAM 50000) heather voles were found in subalpine habitat along the Titan Trail in the Reverdy Mountains, approximately 10 km north of Hyder, Alaska (approximately 55.83° N, 130.03° W; elevations between 1128-1220 m). *Synaptomys borealis* was also sampled at this site.

The distribution of the heather vole is poorly known throughout western North America (Figure 1) and geographic variation has been little studied (for overviews see McAllister and Hoffmann 1988; Nagorsen 1990; Musser and Carleton 1993). Some authorities (Anderson 1942; Cowan and Guiguet 1965; Peterson 1966; Hallett 1999) recognized the distinctiveness of western populations (*P. intermedius* of westcentral British Columbia south to California and New Mexico) and separated them from *P. ungava* in the north and east (southern Yukon Territory and northern British Columbia eastward to Newfoundland) (McAllister and Hoffmann 1988; George 1999); others considered all to comprise a single species (Crowe 1943; Youngman 1975; Honacki et al. 1982; Nagorsen 2004). Hall (1981) speculated that *intermedius* may be a composite of two or three allopatric species (see McAllister and Hoffmann 1988), but the lack of specimens from too few areas has prevented meaningful progress in resolving the problem. Reluctance of this species to enter traps may be the primary factor limiting sample size and study materials (McAllister and Hoffmann 1988).

The taxonomic affinities of newly-discovered populations of heather vole in Southeast Alaska are not immediately evident. Based on the map provided by Hall (1981: 787, as adjusted by McAllister and Hoffmann 1988 and Nagorsen 2004), Alaska's southernmost heather voles could share close kinship with the *P. i. intermedius* group of "western" heather voles occurring in the coastal mountain ranges of adjacent British Columbia. Heather voles from northern Southeast Alaska, on the other hand, might possibly have connection with the "eastern" populations (as *P. ungava mackenzii*) in northwestern British Columbia and southern Yukon Territory. Both of these scenarios presume relatively recent colonization from inland populations following the (ongoing) retreat of the last major glaciation from the region. A similar scenario has been proposed for American Marten (*Martes americana*) (Stone et al. 2002) and other mammals (Cook

TABLE 1. Summary of specimen data from collection notes and records at the University of Alaska Museum (UAM). Alaska Frozen Tissue Number refers to the cryogenic collection administered by UAM. Measurements and abbreviations are as follows: total length-tail length-hind foot-ear from notch (in millimeters)≡mass (in grams); t = testes (length and width in mm), plsc = number of placental scars on right and left uterine horn; F = female, M = male.

UAM Catalog Number	Alaska Frozen Tissue Number	Sex (Reproduction)	Measurements
42371	17262	M (t=2X3)	120-31-19-11≡19
50000	30176	F (plsc: 4R, 0L)	156-37-18-14≡33.9
64239	30178	M (t=3X2)	129-32-17-13≡22.8
64240	30179	M (t=3X2)	115-26-16-10≡14.6

et al. 2001). An alternative hypothesis, however, is that one or more of these populations are remnants of a former coastal population whose origin in the region preceded the last glacial advance (MacDonald and Cook 1996; Fleming and Cook 2002).

The discovery of late Pleistocene fossil remains of *Phenacomys* in limestone cave deposits in the Alexander Archipelago of Southeast Alaska has added historical dimension to these hypotheses. Preliminary analyses of thousands of rodent teeth recovered from *On Your Knees Cave* at the extreme northwest corner of Prince of Wales Island in Southeast Alaska (Figure 1) (Heaton 1995, 2004*; Heaton and Grady 2003) indicate that Heather Voles had been present in the vicinity of this site during the Middle Wisconsin up to the start of, but not during or following, the last glacial maximum (between about 24 000 to 13 000 years ago) (Heaton 2004*; Heaton and Grady 2003). Other

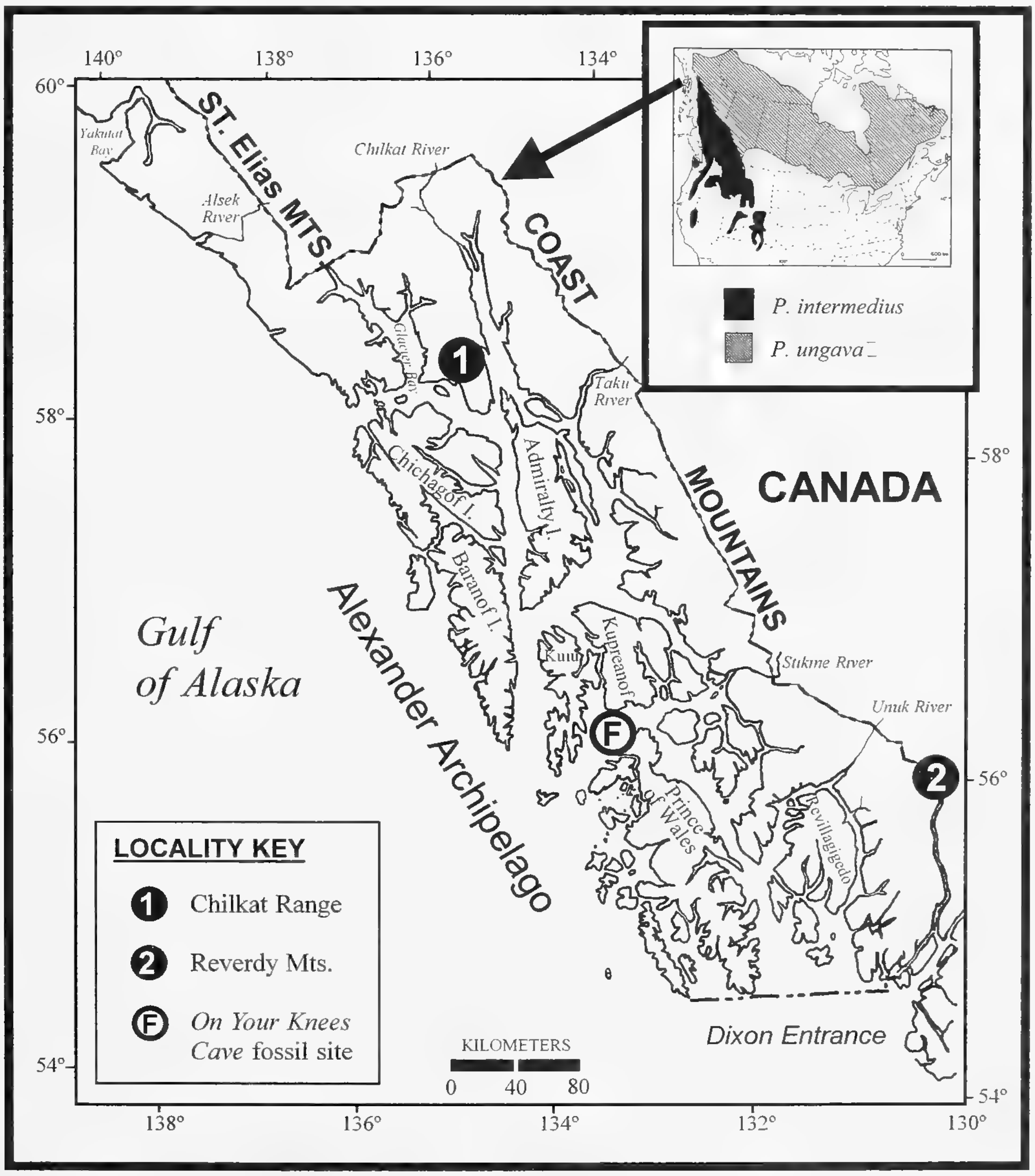

FIGURE 1: Localities of specimens of *Phenacomys* in Southeastern Alaska from Recent and Late Pleistocene sites. Inset range map modified according to McAllister and Hoffman (1988) following subspecific designations suggested by George (1999) and Hallett (1999).

rodent remains discovered in these same pre-glacial deposits were Brown Lemming, *Lemmus trimucronatus*, a species thought absent from the region but recently discovered by UAM in the mountains near Haines, and the Hoary Marmot, *Marmota caligata*, a species now restricted to mainland localities.

How the new records of *Phenacomys* from Southeast Alaska relate to extant and historical populations has yet to be determined. Analyses of samples using modern molecular and morphological techniques could help clarify these relationships and provide a test of alternate hypotheses on the origin and dynamics of the region's biota. Clearly, more samples from more localities are needed. An expanded effort to excavate fossils throughout the region, along with a continuation of survey efforts to further define the current distribution of *Phenacomys* and other mammals that share a deep history in the region (e.g., *Lemmus*, *Marmota*), as well as provide adequate samples for assessment, are needed. The alpine zone of Southeast Alaska is virtually unexplored and future inventories need to target sites above treeline along the mainland as well as on the more mountainous islands in the Alexander Archipelago.

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Extension de l'aire de distribution connue de la Musaraigne fuligineuse, *Sorex fumeus,* dans le nord-est du Québec

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La Musaraigne fuligineuse (*Sorex fumeus*) figure sur la liste des espèces de la faune vertébrée susceptibles d'être désignées menacées ou vulnérables au Québec. Le 7 juin 1999, nous avons récolté un individu mort en bordure de la rivière Saint-Nicolas, à Godbout, dans la région de la Côte Nord. Cette observation constitue une extension de l'aire de répartition connue de l'espèce d'environ 200 km vers le nord-est.

Mots-clés : Musaraigne fuligineuse, *Sorex fumeus*, aire de distribution, Québec.

La Musaraigne fuligineuse (*Sorex fumeus*) est présente dans le nord-est de l'Amérique du Nord, des Great Smokies des Carolines au sud jusqu'au centre de l'Ontario et aux Maritimes vers le nord (Banfield 1977). Au Québec, la mention la plus nordique de l'espèce se situe à Val-Jalbert, aux abords du lac Saint-Jean (van Zyll de Jong 1983). Sa répartition connue vers le nord-est, sur la rive nord du fleuve Saint-Laurent, ne dépasse guère la rivière Saguenay (van Zyll de Jong 1983; Banfield 1977). Cette musaraigne figure sur la liste des espèces de vertébrés susceptibles d'être désignées menacées ou vulnérables au Québec (Beaulieu 1992). Les chercheurs contactés en 1989 n'avaient pas rapporté de capture récente au Québec (Beaulieu 1992) mais depuis, elle a été capturée à divers endroits notamment dans le sud de la province (G. Lupien, communication personnelle).

Le 7 juin 1999, nous avons trouvé un spécimen de la Musaraigne fuligineuse mort, probablement noyé, en bordure de la rivière Saint-Nicolas, à environ 100 mètres au sud de la route 138 à Godbout (49°19'10"N, 67°47'24"O), dans la région de la Côte Nord. L'habitat à cet endroit est une aulnaie, bordée par une sapinière à Bouleau blanc. Aucun autre micromammifère n'y a été observé. Le spécimen de Musaraigne fuligineuse a été récolté pour identification. Les mesures ont été prises sur le spécimen à l'aide d'un vernier à coulisse, par J-F. D. et S. Houde, et elles correspondent à celles de la Musaraigne fuligineuse (tableau 1). Au Québec, la Musaraigne fuligineuse peut être confondue avec la Musaraigne cendrée (*Sorex cinereus*), ayant toutes deux de quatre à cinq dents unicuspides visibles, la limite postérieure du foramen infraorbitaire antérieure ou près de la limite entre les molaires 1 et 2, le trou mentonnier situé à la hauteur du protoconide de la molaire 1, et la mandibule dépourvue de foramen postmandibulaire (Maisonneuve et al. 1997). Elle s'en distingue toutefois par certaines mesures du crâne et du corps (tableau 1). Le spécimen a malheureusement été perdu quelques jours plus tard, jeté par erreur avec d'autres micromammifères morts, mais les mesures prises confirment son identification.

Cette observation constitue une extension d'aire de l'espèce de 200 km vers le nord-est, soit à partir de l'embouchure de la rivière Saguenay (van Zyll de Jong 1983). La Musaraigne cendrée (*Sorex cinereus*), une espèce plus commune au Québec (observation personnelle), a une distribution qui s'étend bien plus au

TABLEAU 1. Mesures comparées du spécimen de musaraigne trouvé sur la Côte Nord, de la Musaraigne fuligineuse et de la Musaraigne cendrée.

Espèce	Longueur du crâne (mm)	Largeur du maxillaire (mm)	Longueur totale (mm)	Longueur de la queue (mm)
Spécimen de la Côte Nord	17,7	4,8	111,4	47,8
Musaraigne fuligineuse	17,5 à 18,8[2]	4,8 à 5,4[2]	110 à 127[1]	40 à 52[1]
	>17,5[3]	>4,6[3]	104 à 125[2]	42 à 54[2]
Musaraigne cendrée	15,2 à 16,9[2]	3,8 à 4,3[2]	92 à 110[1]	37 à 46[1]
	<17[3]	<4,6[3]	75 à 125[2]	28 à 50[2]

[1] Banfield 1977
[2] van Zyll de Jong 1983
[3] Maisonneuve et al. 1997

nord (van Zyll de Jong 1983; Banfield 1977). La découverte de la Musaraigne fuligineuse à Godbout indique que la distribution de certaines espèces de petits mammifères est encore mal connue. En ce sens, il est permis de croire que de futures découvertes seront faites et permettront de mieux connaître les habitats fréquentés par ces espèces et de préciser leur aire de distribution dans le nord de la province. Il est à noter que cette mention de la Musaraigne fuligineuse figure dans l'Atlas des micromammifères du Québec, sans documentation publié en 2002 (Desrosiers et al. 2002).

Remerciements

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Gulls, *Larus* spp., Foraging at Pink Salmon, *Oncorhynchus gorbuscha,* Spawning Runs

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Willson, Mary F. 2004. Gulls, *(Larus* spp.*),* foraging at Pink Salmon, *Oncorhynchus gorbuscha,* spawning runs. Canadian Field-Naturalist 118(3): 442-443.

Small and immature gulls foraged more often on drifting salmon eggs than did large and mature gulls, and large and mature gulls foraged more often on salmon carcasses, at streams in Southeast Alaska. These differences may be related to body size via physical strength and dominance status, as well as foraging experience.

Key Words: Gulls, *Larus* spp., Pink Salmon, *Oncorhynchus gorbuscha,* Southeast Alaska.

Salmon spawning runs attract many foraging birds and mammals (Willson and Halupka 1995) and are clearly an important food resource for wildlife in late summer and fall. Gulls *(Larus* spp.) are among the most numerous predators and scavengers at salmon runs, sometimes occurring in the thousands (Isleib and Kessel 1973). Here I report how four species of gull exploited runs of Pink Salmon *(Oncorhynchus gorbuscha)* at the mouths of streams in Juneau, Alaska.

Study Area and Methods

Most of these observations were made at the mouths of Salmon Creek and Sheep Creek (less than 12 km apart), with some supplementary observations at four other small, nearby streams, within the city and borough of Juneau in Southeast Alaska (ca. 58°30'N, 133°30'W). I observed four species of gulls foraging at or near low tides, usually in the morning, from 27 August to 6 September 2002 (>6 hrs of observation). At any one time, many dozens of gulls were present at the two primary study locations. At low tide, these creeks flow over intertidal deltas, often with several shallow channels used by incoming salmon. I scanned these deltas with spotting scope and binoculars, noting the foraging activities of the gulls and counting the individuals engaged in several distinctive foraging activities. Birds shifted position frequently, using different parts of the deltas; many individuals of the three larger species also changed foraging activity as I watched. Most scans were made at different locations on different days; if more than one scan occurred on the same day and stream delta, they were separated in time by about 30 min. I recorded foraging observations in three categories: foraging on salmon eggs (drifting eggs are common because later spawners often disturb the gravels over the nests of earlier spawners, foot-paddling by gulls also stirs up poorly buried eggs), foraging on salmon carcasses (including some extraction of eggs from living or dead fish), and searching for invertebrates in *Fucus* mats (where amphipods and isopods were common) and tide pools.

TABLE 1. Foraging activity of four species of gull at salmon spawning runs in southeast Alaska.

Species/age class	Eggs	Salmon	Invertebrates	N (observations)
Bonaparte's Gull	82%	–	18%	353
Mew Gull adults	33%	1%	66%	232
Herring Gull adults[a]	31%	58%	11%	26
Herring Gull immatures	80%	20%	–	15
Glaucous-wing adults[a]	11%	87%	2%	362
Glaucous-wing immatures	44%	55%	1%	222

[a]Frequency distributions for adults and immatures were significantly different (χ^2_2 = 88.5 and 7.1, for the two species respectively; $p < 0.05$ in both cases).

Results

Foraging behavior of each species was very consistent among the observed streams, but there were marked differences in foraging among species and age classes (Table 1). The small (ca. 190 g, Sibley 2000) Bonaparte's Gull (*L. philadelphia)* foraged for salmon eggs chiefly by hovering over the streams and plunge-diving for drifting eggs, but they occasionally sought invertebrates in *Fucus* mats or tide pools. Most birds were in nonbreeding plumage, and adults were not distinguished from immatures.

Mew Gulls (*L. canus),* of intermediate size (ca. 420 g, Sibley 2000), waded in the shallows, searching for drift eggs, or hunted invertebrates in *Fucus* mats. They seldom foraged on fish carcasses and then only if no large gulls were nearby. Too few immatures were present for adequate sampling, so all observations pertain to adults.

Both Herring (*L. argentatus)* and Glaucous-winged (*L. glaucescens)* gulls (body mass about 1000-1100 g for both species, Sibley 2000) foraged chiefly on carcasses and on eggs, only rarely visiting the *Fucus* mats on these deltas. Eggs were commonly obtained while wading, occasionally by foot-paddling. Glaucous-wing adults sometimes pulled live salmon from the stream, poking initially at eyes and at the vent area to force egg extrusion. Immatures of both species foraged more often on eggs than did adults, while adults foraged more often on carcasses. Both of these larger gulls often examined very old, bleached and decayed, carcasses that appeared to offer little or nothing edible.

Discussion

Salmon eggs are rich in lipids (Gende et al. 2001, 2004), offering an easily captured and high-calorie food, and brightly colored, so they are easy to see as they drift downstream. Bonaparte's Gulls, Mew Gulls, and immatures of the larger species foraged heavily on eggs. The demands of imminent fall migration for the smaller gulls may provide added impetus for rapid energy acquisition; most Bonaparte's Gulls left the area before the Pink Salmon runs were completely over. The immatures are less experienced foragers than adults, and eggs may be more easily accessed than carcasses. Carcasses are probably less accessible to smaller gulls because the skin is tough and hard to breach and also because the larger gulls (and ravens and eagles) can easily dominate the smaller birds. Glaucous-winged Gulls selectively killed and eviscerated female Sockeye Salmon *(O. nerka)* in shallow streams in western Alaska (Mossman 1958). The foraging differences among gull species here are similar to the observations of Moyle (1966) elsewhere in Alaska.

Other species of wildlife also favor salmon eggs. Bears (*Ursus* spp.) often feed selectively on eggs (and other high-lipid body parts) from live-caught fish (Gende et al. 2001). American Dipper *(Cinclus mexicanus)* chicks, juveniles, and adults feed on drift eggs (Obermeyer et al. 1999; K. E. Obermeyer and M. F. Willson, unpublished observations). Foraging on drift eggs by wildlife has no significant effect on salmon populations, because drift eggs do not survive outside the nesting gravels.

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Sequential Polyandry in Piping Plover, *Charadrius melodus,* Nesting in Eastern Canada

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Amirault, Diane L., Jonathan Kierstead, Peter MacDonald and Larry MacDonnell. 2004. Sequential polyandry in Piping Plover, *Charadrius melodus,* nesting in eastern Canada. Canadian Field-Naturalist 118(3): 444-446.

On Cape Sable Island, Nova Scotia, we confirmed that a banded female Piping Plover (*Charadrius melodus melodus*) produced two broods of chicks during the 2000 nesting season, the second on a beach approximately 2 km from the first. The female abandoned her second brood two days after hatching, leaving the male to complete brood rearing.

Key Words: Piping Plover, *Charadrius melodus,* sequential polyandry, Nova Scotia.

Piping Plovers (*Charadrius melodus)* generally have been thought to be monogamous, with males establishing and defending territories and raising only one brood per season (Wilcox 1959; Cairns 1982; Haig and Oring 1988; Haig 1992). Renesting in Piping Plovers is common if a clutch is lost (Haig 1992) and occasionally occurs if a brood of chicks is lost (MacIvor 1990). In Manitoba, Piping Plovers exhibited sequential polyandrous behavior (Oring 1982; Haig 1992) where some breeding adults had multiple nests and mates (Haig and Oring 1988) after predation or storm events caused nest loss.

The best example of polyandry in shorebirds has been documented in the Spotted Sandpiper (*Actitis macularia)* (Oring and Knudson 1973). Within Spotted Sandpipers, females are larger and more aggressive than males and establish and defend nesting territories. Female Spotted Sandpipers lay several clutches of eggs while different males incubate eggs and complete brood-rearing tasks for each.

Bottitta et al. (1997) published the first observations of Piping Plovers successfully fledging two broods in one nesting season, at Griswold Point in Old Lyme, Connecticut, and Assateague Island National Seashore, along the Maryland and Virginia coast. During the Bottitta et al. (1997) studies (1989-1994), eight Piping Plover pairs successfully raised two broods each within a reproductive season. Although not all birds involved were banded to enable identification of individuals, mates in most cases were thought to have been retained because of plumage characteristics and proximity of second nests to locations of first nests.

The potential for Piping Plovers *P. m. meliodius* to raise a second brood in eastern Canada is thought to be small, owing to the later, and therefore shorter, nesting season associated with a more northerly location. With aid of a banding program, we documented the production of a second brood by the same female Piping Plover in southwestern Nova Scotia during the 2000 nesting season.

Study Area and Methods

Piping Plovers have been closely monitored on two beaches (Daniels Head beach [43°26'N, 65°36'W] and Stoney Island beach [43°28'N, 65°34'W]) on Cape Sable Island in southern Nova Scotia since 1997 (P. MacDonald, unpublished data). Daniels Head beach encompasses a 15-90 m (high-low tide) wide stretch of light-coloured sand extending the full length of the 3.3 km beach, broken by four rocky points and an inlet to a sandy tidal-flat area. Low vegetated (*Ammophila breviligulata* and other grasses) dunes provide a break between the beach and a brackish inland marsh. Stoney Island is a light-coloured sand beach bordered by low, densely vegetated dunes (*Ammophila breviligulata*, grasses, and shrubs). The 15-75 m (high-low tide) wide beach extends 1.8 km in a crescent shape from a rocky point in the south to an embankment in the north. The beaches are separated by an approximately 2 km long coastal stretch characterized by rocky shoreline, a tidal channel, and headland on which a fish processing plant is located (Boates et al. 1994*). Daniel's Head beach supported from three to seven nesting pairs of Piping Plovers in the 1997 to 2000 period. Conversely, the single pair at Stoney Island beach was the only successful nesting event since 1997.

We trapped and banded birds on several occasions during May-July 2000. A modified Weller trap was used to capture adult birds incubating eggs (Weller 1957). A trapped bird was immediately removed from the trap, banded with a United States Fish and Wildlife Service numbered metal incoloy band on the lower right leg (for adult birds) and a Canadian Wildlife Service bicoloured plastic band on the lower left leg (specific to province) and released.

Results

On 24 May 2000, we trapped and banded a female Piping Plover incubating four eggs on Daniels Head beach. Four chicks hatched from this clutch on 30 May. The female was not observed with the brood after 13

June, at which time only one chick remained. This chick was considered fledged on 25 June. The adult male remained with the juvenile and both were observed together until 5 July. A nest containing three eggs was discovered on 23 June on Stoney Island beach. Four eggs were confirmed on 25 June. We trapped a female bird on this nest on 29 June and her leg band number confirmed that this individual was the female banded on 24 May at Daniels Head beach. This second nesting event appears to have been completed with a different mate as the male from the first nest remained with the surviving chick until 5 July, well after fledging. The second pair hatched four eggs on 18 July and the female was not observed with the brood (4 chicks still remained) after 20 July. One chick from this brood was considered fledged on 13 August, the last day both the juvenile and adult male were observed. Males from each nest were unbanded, facilitating identification of which adult (male or female) was present with the chicks.

Discussion

Although Haig and Oring (1988) documented polyandry in Manitoba, their observations included renesting following nest loss but never more than one brood per nesting season. Our observations represent the first documented occurrence of a female Piping Plover relocating to produce a second brood within a nesting season on Canadian nesting grounds. Bottitta et al. (1997) were the first to report Piping Plovers raising more than one brood in a season. However, their occurrences were documented in the United States and on a single nesting beach. Although closely related species such as Killdeer (*Charadrius vociferus*) and Snowy Plover (*Charadrius alexandrinus*) are known to produce two broods, this behaviour is thought to be extremely rare among Piping Plovers (Wilcox 1959; Cairns 1982; Whyte 1985; Haig and Oring 1988; MacIvor 1990; Strauss 1990; Loegering 1992). Thus, most second nest attempts are renests following nest loss. Presumably, the second nest on Stoney Island beach was initiated 18-19 June as Piping Plovers average 6-8 days to complete laying of a full clutch (Haig 1992). The interval between the last sighting of this female with her first brood (13 June) and the calculated initiation of her new clutch is brief (5-6 days). However, Piping Plovers have been known to initiate renesting after a lost clutch in as few as 4 days (Whyte 1985; Haig and Oring 1988; MacIvor 1990; Loegering 1992).

Bottitta et al.'s (1997) long-term study documented several examples of two broods being produced within a nesting season, all of which were thought to have been completed with the same mates. That is consistent with renesting Piping Plovers generally retaining the same mate (Wilcox 1959; Whyte 1985; Haig and Oring 1988; MacIvor 1990). However, in southern Manitoba, renesting birds often chose a new mate in cases of high predation and nest loss (Haig and Oring 1988). Our record of intra-year mate switching suggests that switching may occur in cases where nest loss has not occurred and may increase an individual's productivity.

Several studies have indicated that it is not uncommon for one adult, usually the female, to abandon its brood prior to chicks fledging (Cairns 1977; Whyte 1985; Haig 1987). However, this is the first documented case of a female plover abandoning its brood in order to produce another nest. These observations indicate that a small number of females may leave early to renest and leave further parental care to the male.

Previously documented cases of sequential polyandry in Piping Plovers have been in circumstances associated with high predation rates and catastrophic storm events (Haig and Oring 1988; MacIvor 1990). Our observations demonstrate that sequential polyandry may also occur where there is potential for increasing productivity. The documentation of a second brood produced by one female underscores the importance of having early nest attempts succeed. Such success would allow greater chance for a second nesting event to occur, resulting in greater productivity. MacIvor (1990) reported that more young fledge from first nest attempts than from renests and from early versus late nests. MacIvor (1990) suggested that increased vulnerability of chicks later in the breeding season (July-August) was due to a greater human presence on beaches then. Haig and Oring (1988) reported greater parental care on first nest attempts versus renests; however, no difference in hatching or fledging rates was noted. Therefore, measures to enhance nest success such as placing predator exclosures (Bottitta et al. 1997), symbolic fencing, and beach guardian patrols may be particularly important for first nest attempts as a successful early nest may increase reproductive success.

The incidence of producing two broods within a nesting season is thought to be fairly low, but documentation of one apparent double nesting event by an individual has significant implications for conducting population counts of adult Piping Plovers. This event justifies adherence of any Piping Plover census to a brief window of time, as in the absence of information such as provided by this study, the second nesting event might have been erroneously recorded as two additional individuals. Counts within a prescribed time frame will decrease the potential for double-counting birds that have relocated to renest or produce a second brood. In past censuses, observers often have considered an adult found on a nest or a single adult with a brood as a nesting pair (i.e., two adult birds), even if only one adult was observed. Our observations suggest that a small proportion of late-nesting pairs may actually be successful early nesters on a second nest attempt. Hence, danger in overestimating numbers

exists when counting adult Piping Plovers outside a census window as our observations indicate not all birds retain the same mate or beach in a nesting season.

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American Dipper, *Cinclus mexicanus,* Preys Upon Larval Tailed Frogs, *Ascaphus truei*

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Morrissey, Christy A., and Roberta J. Olenick. 2004. American Dipper, *Cinclus mexicanus*, preys upon larval tailed frogs, *Ascaphus truei*. Canadian Field-Naturalist 118(3): 446-448.

The American Dipper (*Cinclus mexicanus*) is an aquatic songbird that inhabits fast-flowing mountain streams in western North America. Although dippers are known to feed primarily on aquatic invertebrates, they will also eat juvenile fish and salmon eggs when available. In 2002, while monitoring and photographing nesting activities of the American dipper, we observed and photographed adult dippers capturing Tailed Frog (*Ascaphus truei*) tadpoles and feeding them to their young. This note is intended to document a rarely observed occurrence and identify interactions between two relatively uncommon species.

Key Words: American Dipper, *Cinclus mexicanus*, Tailed Frog, *Ascaphus truei*, feeding, Chilliwack River, British Columbia.

American Dippers (*Cinclus mexicanus*) are North America's only truly aquatic songbirds occupying mountain streams of western North America from Alaska south to Mexico (Kingery 1996). Dippers are known to feed almost exclusively on in stream fauna, diving underwater and probing among the rocks for benthic invertebrates and small fish (salmon and trout) as well as fish eggs (Kingery 1996). To our knowledge, there have been no previous records in the literature of dippers feeding on amphibians. However, while studying and photographing American Dippers in southwestern British Columbia, we observed dippers

FIGURE 1. Adult American Dipper delivering Tailed Frog tadpole to nestlings at a nest under a logging road bridge on Tamihi Creek, British Columbia, in June 2002. Photograph by Roberta Olenick.

on several occasions feeding on Tailed Frog (*Ascaphus truei*) larvae.

Field work on the American Dipper was conducted in the Chilliwack River watershed located in the Cascade Mountains of southwestern British Columbia, Canada. While observing dipper nests in June and July 2002, we noted at least two different pairs of American Dippers, attending separate nests on Tamihi Creek, a tributary of the Chilliwack River (49.02 N, 121.50 W, elevation 545 m) feeding Tailed Frog tadpoles to their young. Roberta Olenick photographed those dippers delivering Tailed Frog tadpoles to nestlings or fledglings at each nest site (Figures 1 and 2).

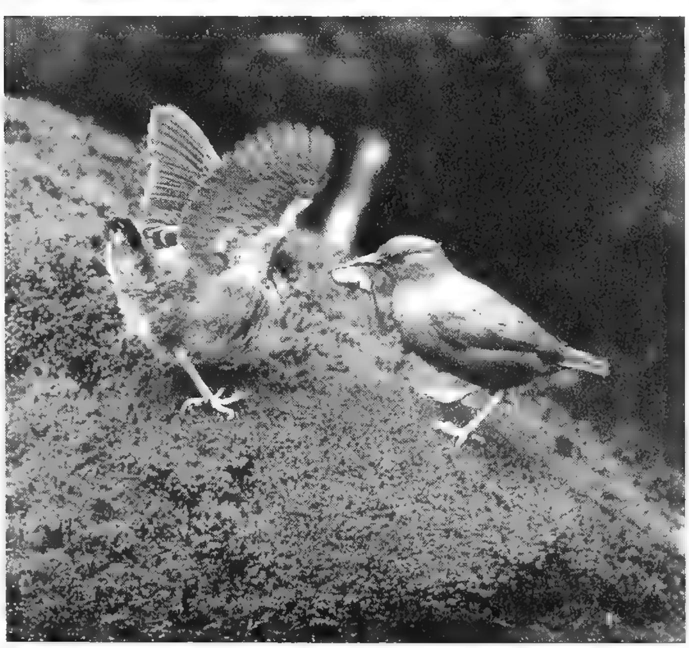

FIGURE 2: Adult American Dipper delivering Tailed Frog tadpole to newly fledged dipper on Tamihi Creek, British Columbia in July 2002. Photograph by Roberta Olenick.

On one occasion, an adult dipper captured a very large Tailed Frog tadpole (estimated length 5-6 cm) and attempted to feed it to one of its fledglings. The fledgling dipper struggled to swallow the large prey item without success. Several times, the adult dipper retrieved the tadpole, knocked it vigorously against a rock and manipulated the large wide head in its bill. Eventually, after several minutes of handling by the adult, the fledgling dipper managed to swallow the large tadpole whole.

During routine annual benthic invertebrate collections in April 1999-2002, we infrequently captured Tailed Frog tadpoles in our Surber samplers using kick-sampling procedures. Larval Tailed Frogs have a distinct round mouth, well adapted to use as suction onto the surface of in stream rocks, making them relatively easy to identify. Tailed Frog larvae were found on several tributaries of the Chilliwack River including Tamihi Creek, Borden Creek, and Chipmunk Creek. It is worth noting that all of these creeks have present or past logging activity which is thought to limit the presence and abundance of Tailed Frogs through increased water temperatures and siltation (Nussbaum et al. 1983). No other similar species of amphibians occupy fast flowing stream habitat in our study area.

There are few known predators of *Ascaphus truei*. Tailed Frog tadpoles have been identified as impor-

tant prey for larval Pacific Giant (*Dicamptodon ensatus*) and Cope's salamanders (*Dicamptodon copei*) and Red-legged Frogs (*Rana aurora*) (Bury 1968; Jones and Raphael 1998). Observations of garter snakes (*Thamnophis* spp.) (Karraker 2001) and Cutthroat Trout (*Salmo clarki*) depredating Tailed Frogs have also been previously reported (Daugherty and Sheldon 1982). We found only one instance in the literature where American Dippers were cited as being a potential predator of Tailed Frogs, in Butler Creek, Montana (Daugherty and Sheldon 1982). However, it was not clear whether those authors actually observed dippers feeding on Tailed Frogs. Given that the Tailed Frog is a provincially blue-listed (vulnerable) species in British Columbia and of special concern in the national COSEWIC listing, documentation of these rare observations is important.

Tailed Frogs are endemic to the Pacific Northwest. They range from British Columbia south to California, occupying western mountain streams and humid forests throughout a 15-20 year lifespan (Daugherty and Sheldon 1982). Larvae take from 1 to 4 years to metamorphose into adults in cool fast streams (Bull and Carter 1996). Their distribution directly overlaps that of the American Dipper, which occupies the same habitat and geographic range. Both species are considered sensitive to environmental impacts in mountainous watersheds from anthropogenic sources (Nussbaum et al. 1983, Kingery 1996). Given that these two species occupy the same habitat and geographic range, American Dipper predation of Tailed Frogs may be more widespread than previously acknowledged.

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Piping Plover, *Charadrius melodus,* egg viability after seawater immersion

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Four observed nest histories indicate Piping Plover eggs are able to survive immersion in seawater, but little is known regarding their hardiness. As Piping Plover nests are often exposed to tidal flooding, their eggs may be relatively resistant to inundation by seawater. Therefore, we suggest that replacing eggs recently flooded or washed out of nests is a viable option for the recovery of individual nests.

Key Words: Piping Plover, *Charadrius melodus melodus*, flooding, high tide, hatching success, viability, Prince Edward Island, Nova Scotia.

The Atlantic Coast population of Piping Plover (*Charadrius melodus melodus*) is listed as *Endangered* in Canada and *Threatened* in the United States (Goossen et al. 2002; U.S. Fish and Wildlife Service 1996). Nesting Atlantic coast Piping Plovers prefer flat coastal beaches with sand and pebble substrate (Boyne and Amirault 1999; Burger 1987; Cairns and McLaren 1980). The male scrapes a shallow depression in the substrate between the mean high water mark and the edge of adjacent dunes or vegetation (Burger 1987; Cairns 1982; Haig 1992). The young hatch after approximately 28 days and leave the nest within hours of hatching (Cairns 1982; Haig 1992). Nesting areas are often flooded by storm-induced overwashes (Cairns and McLaren 1980) and high water levels destroy many plover nests each season (Sylvester 1991).

Four cases in which flooded Piping Plover eggs remained viable were documented during the course of regular monitoring at Prince Edward Island National Park and in southern Nova Scotia. The following nest

histories confirm the viability of flooded eggs.

Case 1. On 29 May 1992, a nest at Cavendish Sandspit in Prince Edward Island National Park (46.5036°N, 63.4408°W) was completed with four eggs. On 5 June, the nest was submerged by a high tide. Both adults were present but not searching for their eggs or vocalising excessively. Their eggs were removed from the nest, temporarily replaced with clay eggs and returned to the nest later that day. The shells that had lined the nest were covered by wet sand and some water still remained in the nest. After a brief period, one of the adults returned to the nest and began to incubate and the second adult arrived at the site shortly thereafter. On 24 June, four chicks hatched after 26 days of incubation. The four chicks were considered to have fledged on 14 July.

Case 2. On 3 June 1999, a nest at Cavendish Sandspit (46.5028°N, 63.4322°W) was completed with four eggs. On 17 June, this nest was flooded and the eggs were found approximately 1 m from the nest in 10 cm of water. Both adults were present and appeared agitated. The real eggs were removed and clay eggs were placed in the nest. One severely cracked egg was discarded and the three undamaged eggs were returned to the nest once the water receded. One chick hatched on 30 June, and a second was observed on 1 July. The remaining egg was abandoned. Only one chick survived to fledge and it was banded on 12 July. This chick was recaptured as a breeding male on the same beach in 2001.

Case 3. On 17 June 1999, a nest with three eggs at Cavendish Sandspit (46.5047°N, 63.4483°W) was flooded without damage to the eggs. The eggs were found under 10 cm of water, more than 1 m from the nest. They were replaced with clay eggs. An adult was observed incubating the clay eggs approximately 1.5 hours later. The real eggs were then replaced and both adults returned within 30 minutes. Only one adult was observed on subsequent visits and the nest was considered abandoned on 20 June. The eggs were collected on 22 June, candled, found to be viable and placed in an incubator. The eggs were candled again on 30 June, when further growth and movement was observed in all 3 eggs. The eggs were successfully fostered to another Piping Plover pair on 3 July, but were taken by a predator on 4 July. The eggs from this nest were not only flooded, but endured a 24-48 hour lapse in incubation without any apparent decrease in viability.

Case 4. A nest with three eggs was discovered on 12 June 2001 at Sebim Beach in Sand Hills Provincial Park, Nova Scotia (43.5311°N, 65.5580°W). The full clutch remained on 25 June, but the high tide had completely overwashed the nest and the sand remained wet. Only two eggs remained on 11 July, and incubation was confirmed on 13 July. One abandoned egg remained in the nest on 16 July. On 18 July, a recently hatched chick (<5days of age) and one adult were observed. The development timeline indicates a protracted incubation period of at least 32 days. Neither chick nor adults were observed after 18 July, and the rearing period was too short for the chick to have fledged successfully.

No information is available on the resistance of Piping Plover eggs to submersion (Haig 1992). Ward and Burger (1980) found that some embryos of Herring Gull (*Larus argentatus*) eggs could remain viable after immersion in cold seawater. As Piping Plover eggs have long been exposed to selection due to tidal flooding, they may be relatively resistant to the effects of inundation (Ward and Burger 1980). Piping Plovers exhibit strong parental tenacity to incubate and tend eggs (Prellwitz et al. 1995) and it is likely that their quick resumption of incubation of eggs after flooding increases the probability of successful hatching. These nest histories confirm that some Piping Plover embryos can survive immersion in seawater, and that replacing eggs washed out of recently flooded nests will increase the survival of individual clutches.

Protracted incubation periods due to nest cooling have been recorded for Piping Plovers and other shorebirds (Cairns 1982). Therefore, eggs believed to have been immersed in seawater, but still present in the nest cup, should not be removed as long as the adults continue to incubate and the incubation period is shorter than 40 days.

Acknowledgments

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A Tribute to Loris Shano Russell, 1904-1998

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It was somewhat daunting to try to write the story of a man as accomplished as Loris Shano Russell. On one hand, it is relatively easy to record or list the numerous publications and awards. On the other hand, it is much harder to see through all of the accomplishments in order to glimpse something of the man himself. I got to know Loris only later in his life, as the one tasked with arranging his weekly visits to the Royal Ontario Museum (ROM), and so in this report I have relied on many who knew him earlier, in particular, John E. Storer.

Russell's accomplishments were many. He was one of the last of the "old school" of palaeontologists, those who studied and published original findings in geology, stratigraphy, and both fossil invertebrates and vertebrates: a broad concept rather foreign to most of us in today's specialized world. He was extremely organized, and was meticulous with everything he did, whether it was science, museology, ham and military radio operation, or administration. He was unfailingly polite and dignified, and always came to work wearing jacket and tie; about the worst name he ever called anyone in public was "stuffed shirt", a phrase he reserved for H. F. Osborn.

Loris died in July 1998, in his 95th year, and was predeceased by his beloved wife Grace, in March 1998. Their partnership of 60 years is the stuff of legends. They did everything together, from hosting museum dignitaries at their home, to attending antique markets, to working in the dirt and the heat in the badlands of Alberta collecting fossils (Figure 1). Grace never did learn very much about the fossils, but that didn't matter to her at all – she was there for, and with, Loris. When he was hospitalised in 1990, Grace visited several times a week, as long as the Wheel-Trans vehicles were available to take her there, as she was then not very mobile herself. Their separation at this time must have been very difficult for both of them. Grace was an out-

FIGURE 1. Grace and Loris Russell, 10 June 1986, in the Red Deer River valley, at the site where the holotype of *Edmontosaurus regalis* was collected by Levi and C. H. Sternberg in 1912. Photo by Maurice Stefanuk. (Photo courtesy ROM Archives).

spoken fan of her husband, and she was as forthright with people as he was quiet and formal. Their differences were marked, yet their partnership flourished. They had no children, and the topic was never discussed with others. Many "Grace" stories exist; several are related in Churcher (2003). Francis Cook passed on the following story. At the NMC (National Museum of Canada, now the Canadian Museum of Nature) staff party for Loris when he was leaving and moving to the ROM, Grace invited everyone to visit them in their new quarters in Toronto and to use their swimming pool. Loris quietly yet respectfully deflected her enthusiasm by pointing out that they were moving to an apartment building and he was not sure that it included privileges for an infinite number of visitors to use the pool.

Loris Shano Russell was born in April 1904, in Brooklyn, New York. His parents were Matilda Shano of Newfoundland, and Milan Winslow Russell of New York. Loris' middle name came from his mother's maiden name, of course, and Loris told me that "Shano" was an anglicised version of the French "Chenaud". As for his unusual first name, Loris told me that his parents simply were looking for something different when they picked it; there was no family history to the name.

In 1908, when Loris was four, his family moved to Calgary, Alberta, where he grew up. He attended both public and high school in Calgary, and must have had a keen early interest in science, judging by early photos of him (Figures 2 and 3). He attended the University of Alberta, Edmonton, and graduated with a B.Sc. in Geology in 1927; however, he had already started publishing before graduation! He spent some time prospecting the Paskapoo Formation in Alberta near his family's home: his first two reviewed papers (published in 1926) are both on fossils of the Paskapoo. By this time he must have already encountered the Sternberg family of dinosaur collecting fame, as there is a 1923 photo of Loris excavating in the Red Deer River Valley, north of the Bleriot Ferry (Figure 4). Even at this early point in his career, his published papers were representative of his broad-ranging interests: one is on fossil molluscs, and the other on the fossil mammal *Catopsalis*. Fossils were not his only early interest, however. Before his first refereed papers on fossils, he had published a note on Alberta's birds in 1923.

At Princeton University, he studied under William Berryman Scott, the famous geologist and palaeontologist. W. A. Parks, then Head of the Department of Geology at the University of Toronto (UT), had wanted him to study at the UT, but Loris thought that it would be better to study with Scott, one of the very few European-trained professional vertebrate palaeontologists then teaching in North America. Loris was awarded his M.A. in 1929, and his Ph.D. in 1930, for a dissertation entitled "Stratigraphy and Paleontology of the Uppermost Cretaceous and Lower Tertiary Formations of Alberta", a copy of which is in the ROM library. By graduation he had published at least a dozen papers, including papers on subjects as diverse as fossil pelecypods, gastropods, fish, turtles, dinosaurs, marsupials and mammal tracks. These papers may have partly resulted from his summer work as a student assistant in 1925-1929 at the Research Council of Alberta in Edmonton.

FIGURE 2. Loris Russell, 1920. Photographer unknown. (Photo courtesy ROM Archives).

After graduating from Princeton in 1930 at the age of 26, he moved to Ottawa and served as Assistant Palaeontologist for the Geological Survey of Canada (GSC) until 1936, and an Assistant Geologist in 1937. During this period (1930-1937), he published over two dozen papers, again on a wide variety of topics: besides the requisite geological and stratigraphic works, there were a number of papers on fossil mammals and fresh-water molluscs, with smaller contributions on turtles, plesiosaurs and dinosaurs. Because of the utility of molluscs in biostratigraphy, many of his earlier works concentrated on these fossils. Of course his interests were not all palaeontological, and he joined the Ottawa Field-Naturalists' Club in 1933. He later became an honorary member of this organization in 1972, after serving as Vice-President for 1954-1956, and as President for 1957-1958.

FIGURE 3. Loris Russell, 1922. Photographer unknown. (Photo courtesy ROM Archives).

During his initial period in Ottawa (1930-1937) Loris met his future wife and constant companion of 60 years, Grace. Grace Evelyn LeFeuvre was eight years younger than Loris. Her mother was born in Montreal of Irish stock, and her father had immigrated to Canada from Jersey, in the Channel Islands. Grace and Loris had met by arrangement of their mothers. While working at the GSC in Ottawa, where he could take Grace out on dates, Loris was offered the position of Assistant Director of the Vertebrate Section of the then separate Royal Ontario Museum of Palaeontology (ROMP), in 1937. This position came about due to the death of W. A. Parks in 1936, and Parks' protégé, Madeleine A. Fritz, simultaneously being appointed Assistant Director of the Invertebrate Section of ROMP. He considered turning down the offer, because he did not want to be far from Grace. The only solution was marriage, and his proposal was to the point: "I'm not going there without you". It appears he may have, at least briefly, because he moved to Toronto in 1937, and they were not married until 1938. Upon their marriage, Grace had to give up her nursing career, as only one income per household was allowed during the Depression.

With the Assistant Directorship at the ROMP came an Assistant Professorship at the UT, in Palaeontology. However, this work was interrupted by the Second World War. With his ability as a ham radio operator (Figure 5), he served from 1942 to 1945 in the Royal Canadian Signal Corps. He first learned this skill in 1922, an interest that he may have gotten from his father, who was a telegrapher for the railway (although his father had died earlier in 1911). At war's end, he was

FIGURE 4. Loris Russell (right) and C. M. Sternberg (left) excavating an *Edmontosaurus* skeleton in the Red Deer River valley, 1923. Photo by J. E. Thurston. (Photo courtesy ROM Archives).

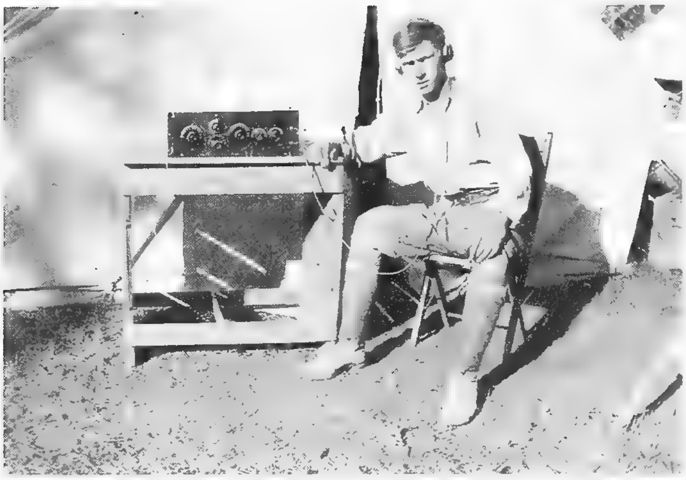

FIGURE 5. Loris Russell, circa 1922. Photographer unknown. (Photo courtesy ROM Archives).

transferred to the Reserve with the rank of Major. He continued an interest in communications, and collected early telegraph and other communications equipment, which since has been donated to the Museum of Science and Technology in Ottawa. In 1946 he was appointed Director of the ROMP and in 1948 Associate Professor at the UT. During 1937-1950 he continued his studies of fossil vertebrates, producing some two dozen papers on fishes, dinosaurs, creodonts, titanotheres, horses, and mastodons, as well as others on the geology of Alberta, fossil gastropods, eurypterids and even living rattlesnakes!

In 1950 came the offer to become Chief of the Zoology Section at the NMC, an offer he could not resist. He and Grace returned to Ottawa, and remained there for the next 13 years. In 1956 he was appointed Director of the Natural History Branch of the NMC (Figure 6), a post that he held until 1963. This time at the NMC was arguably the single most important part of his career as a research museum administrator, which he filled with steady competence, vision and perceptive guidance of staff activities. He hired several productive research and curatorial staff, including Wann Langston, Don McAllister and Arthur Clarke, who shared Loris' professional interests in vertebrate palaeontology, ichthyology, and malacology, respectively. He profoundly influenced the direction of the Canadian natural sciences even outside his own fields of interest. For instance, in 1955 he suggested to invertebrate zoologist E. L. Bousfield that, as a staff member of a national institution, he might consider field studies on the Canadian Pacific coast and break from a previous eight-year Ph.D. obsession with the Atlantic coast. This perceptive suggestion led to the discovery of a diverse, major fauna of amphipod crustaceans of which, during the next 30+ years, more than 200 species and higher taxa were newly described.

This period (1950-1963) must have been a very busy time for him, because in addition, in 1958 alone, he was appointed Acting Director of the Human History Branch at NMC, President of the Society of Vertebrate Paleontology, President of Section IV (Geology) of the Royal Society of Canada and he received an honorary LL.D. from the University of Alberta. He later became the President of the Canadian Museums Association (CMA) in 1961, and was awarded the Willet G. Miller Medal from the Royal Society of Canada (RSC) in 1959. With respect to the RSC, at the time of his death in 1998 he was the most senior member (by seven years over three other elderly fellows) of the entire RSC roster of approximately 1500 names, having been elected at the remarkable youthful age of 32 (in 1936), and with 62 years of mostly active participation in this select group of Canadian scientists.

While at the NMC, Loris always had the deep respect of the staff, even though he had a bit of difficulty adjusting to the fact that they were no longer required to work Saturday mornings, as they had when he joined the GSC in the 1930s. When the NMC staff complained in winter about the cold and drafty Victoria Memorial Museum building where they all had offices, Loris quietly remarked that when Dr. Rand (Chief Zoologist from 1942-1947 and a very productive staff member) was there, he just put on an overcoat and went on working. During 1950-1963, he wrote nearly 60 papers, with a broad range of topics: geology, eurypterids, molluscs, fishes, acanthodians, champsosaurs, carnivores, horses, and rabbits. Also during this time he produced more synthetic papers that included discussions of mammalian migrations, continental zoology of the North American Pleistocene, the geological record of evolution, as well as some on museology. These later papers were unlike anything he had written before, and spoke of a greater involvement in the museum community. Examples are several reports on television in museums, out-of-doors museums, plastics in the museum, and historical conservation along the St. Lawrence Seaway.

Loris was intrigued by museums and was involved in the earliest days of the CMA. He was a forward-thinking museologist, whose central tenet could be summed up as: "Museums are doing their job when they are telling stories to the public". This was not the prevailing thought in the 1960s, when the object was supposed to speak for itself, aided by lighting and gadgets, but it seems to be the popular notion once again, where story-centred galleries are becoming common.

Although Loris may well have had a lifelong interest in material culture, it was during this period that this interest blossomed; being the President of the CMA from 1961-1963 and Acting Director of the Human History Branch of the NMC no doubt spurred it on. Constrained by a lack of time to do much palaeontological research while handling administration, Loris decided he would try to apply scientific methods to some research in material history, as an experiment. He chose oil lamps as a subject for research, perhaps as a manifestation of industrial development coupled with social history, and it kept him "occupied and

broke" for years. Loris and Grace visited antique shops together, often in small towns on their way to do palaeontological fieldwork. Some of these adventures are described in his 1969 *Rotunda* article. His habit of meticulously documenting and labelling everything, plus his deep-seated love of a good story (he claimed it came from growing up in the "Wild West"), put him in the position to do ground-breaking research in material culture. Loris developed a superb collection of well-documented lamps, which were later kept in glass display cases in their Toronto apartment; these have since been donated to the ROM. Several books, *A Heritage of Canadian Light* (1968), *Handy Things to Have Around the House* (1979), and *Every Day Life in Colonial Canada* (1980) resulted from this research. These are still standard references today; indeed, *A Heritage of Light* was reprinted in February 2003 by the University of Toronto Press. He became a speaker in demand at various material culture conferences over the next few decades.

In 1963, Loris left NMC under some controversy. Upheaval in the administrative ranks of the NMC made for some messy politics, which Loris did not care for. Returning to Toronto and the ROM, he became the Head of the Life Sciences Division at the ROM, and a year later, he filled the newly created position of Chief Biologist. By that time, the five former Royal Ontario Museums (zoology, palaeontology, mineralogy, geology and archaeology) had been amalgamated into a single institution under one Director. Much of his continued success at ROM was due to Anne Liebeck, Loris' able secretary (Figure 7). She guarded the entrance to Loris' office and answered his telephone, so that he could continue his studies virtually without interruption. In 1964, he received a Diploma with Distinction from the Museums Association of Great Britain. With Loris' return to Toronto came a professorship in the Department of Geology at the UT. He took on three Ph.D. students before retiring: John Storer (graduated in 1970), and Paul Ramaekers and Mark Wilson, both of whom graduated in 1974. Loris officially retired in 1970, when he was appointed Professor Emeritus at the UT in 1970, and Honorary Curator at the ROM in 1971. Loris continued to serve the scientific community after retirement – he was elected in 1971 to the Presidency of the Royal Canadian Institute, and in 1972 to the Presidency of the International Palaeontological Union, a four-year term. He published another 36 papers during this time, with a familiar breadth of topics. Several papers hinted of things to come: his museology papers concentrated on lighting and lamps, and his articles on "Tertiary Mammals of Saskatchewan, Part 1" and "The Great Saskatchewan Mouse Mine" began a series of papers on these important faunas from Saskatchewan. As well, Loris' paper on "Body temperature of dinosaurs and its relationship to their extinction" in 1965 marks the first, and often overlooked, discussion in the English scientific literature of what was later to become a revolution in thinking: dinosaurs as active "warm-blooded" animals. Grace often cited this paper as one of the reasons she was so proud of "her hubby". It was not a secret wish of Loris' that perhaps Bob Bakker and John Ostrom (the oft-cited originators of this hypothesis) and others might have given him more credit for this early insightful work.

FIGURE 6. Loris Russell, 8 November 1956, as Head of the Department of Natural History, National Museum of Canada. Photographer unknown. (Photo courtesy of the CMN Archives, negative #J4171).

His official retirement only meant less administration. He continued fieldwork in Alberta each summer with Grace and others, well into his eighties, until at least 1988, supported by NSERC (Natural Science and Engineering Research Council of Canada) grants. These grants and the subsequent fieldwork meant that he actively published papers until about 1990, with over 40 contributions since retirement. He continued to come into his ROM office daily from 1971 until about 1990, when he first entered hospital for a hip-replacement operation. He never left hospitals after the first operation. From 1994 until 1997, while still wheelchair-bound due to a second failed hip replacement operation, I arranged that he visit ROM one day a week (except during winters) using Wheel-Trans services. During these visits he worked on his last manuscript, concerning the biostratigraphy of the Horseshoe Canyon Formation. Although this paper was never published, staff at the Royal Tyrrell Museum of Palaeontology and the Canadian Museum of Nature plan to publish a paper in the near future on the biostratigraphy of the Horseshoe Canyon Formation rec-

FIGURE 7. Loris Russell and Anne Liebeck at ROM, 1971. Photo by L. R. Warren. (Photo courtesy ROM Photography).

ognizing Loris' essential contributions by including him as a posthumous co-author. Many important palaeontological contributions came from this post-retirement period, for example, the series of papers on the Tertiary Mammals of Saskatchewan (Parts 2 through 7). More awards came late in his life, in particular, the Canadian Silver Jubilee Medal in 1978, the Billings Medal from the Geological Association of Canada in 1984 and the Romer-Simpson Medal from the Society of Vertebrate Paleontology in 1992.

As Tokaryk (1998) noted, much of Loris' scientific work was accomplished solo, judging by the rarity of co-authored publications (only 10 out of more than 200 papers published over 70 years have co-authors). This was partly due to the paucity of other Canadian palaeontologists at the time (although he was ably assisted, or worked with, a number of others in the field), but mostly to do with the fact that he could handle both the geological and palaeontological parts of his chosen projects. A measure of the impact of his work can be taken by counting the number of his papers that were abstracted in the German abstract series Palaeontologishes Zentralblatt (after 1950 called Zentralblatt für Geologie und Paläontologie, Teil 2) or Neues Jahrbuch für Mineralogie, Geologie und Paläontologie (after 1942 called Zentralblatt für Mineralogie, Geologie und Paläontologie). Between 1927 and 1989, I found 68 Russell papers had been abstracted, by a total of 15 different reviewers (besides those who wrote anonymously), although more than half of this total were written by Jaworski or Wenz on molluscs and von Huene, primarily on dinosaurs.

He was an adventuresome scientist, always willing to strike off in a new direction. While on holiday with Grace in Hawaii, he collected some fossil land snails at the famous Diamond Head locality of picture postcard fame. A drawer of this material remains at the ROM, labelled and researched, although he never did publish on them. Nor was he afraid of being wrong, or did he mind greatly if new research invalidated a few of his ideas: that was the way science worked. As long as the work was careful and the facts were straight, then this was fine with him, an admirable quality in a scientist!

Another quality that many people noticed in Loris was his phenomenal memory for field localities. He really could find fossil localities he hadn't seen in 40 years. His successes were legion, so the few exceptions stood out, and yet all of these exceptions seemed to have complicating factors. For instance, he was frus-

trated about not being able to relocate the Calgary Paskapoo Formation localities he collected as a young student, only to realise that housing developments had probably covered the area. He tried many times to find Brown's (1914) Erickson's Landing locality. Although in Russell (1929) he reported relocating this locality, Krause (1978) expressed some doubt about this, and Loris must have harboured some doubts himself. Eventually, as reported by Fox (1990), Loris concluded that there was no way to determine from exactly which level the slump block containing the fossils was derived, and so he never was able to collect significant additional material.

Certainly Loris had a happy outlook on life, and he taught by example, both in the field and in the laboratory. He was an inspiring influence to all who worked with him. He was also the kind of person who would retreat to his workshop to solve design problems, perhaps a legacy of his ham radio days. He designed a unique machine for feeding a thin stream of washed fossil concentrate onto a rubber belt (Figure 8), the movement of which was controlled by a foot pedal. The belt passed under a microscope, allowing him to focus on, and select out, any fossils of interest with his free hands. Uninteresting concentrate rotated off the belt and into a box of scrap. We have preserved this machine at the ROM; perhaps someday others will use it. It was known by words beginning with the letter 'M', such as 'Miraculous Moving Miocene Mouse Machine'. For work on site at the Kleinfelder Farm locality in Saskatchewan (appropriately enough called the 'Mouse Mine'), he also designed two rotary sieves, described in his 1970 *Rotunda* article.

Although Dr. Russell (as he was known) seemed a little stiff and intimidating with some people, he actually had a wry yet somewhat playful sense of humour that surfaced quietly with those he knew well. He was quite amused by the ironies of growing older. On a couple of occasions he observed: "We used to call Scott and Osborn and their generation the 'old boys', and look how things have turned out now". He would tell the story of being a young geological assistant in the 1920s when one evening he got some sort of buzzing insect stuck in his ear. On asking another assistant, who was a medical student, what he should do, he was told "Well, take it out of there!". Loris' father was a religious fundamentalist, so Loris learned the Bible while young. In his later years he was not religious, but appreciated and was amused by the fundamentalist side of Western life. He liked to recount Charlie Sternberg's remark "My, aren't we clever", when William "Bible Bill" Aberhart (Dean of the Calgary Prophetic Bible Institute) stated in a radio sermon that palaeontologists were actually manufacturing fake dinosaur bones in seclusion in the badlands. At a gathering for an NMC staff member about to be married, Francis Cook noticed Loris was drinking milk, whereas the rest of those in attendance were

FIGURE 8. Loris Russell with the Marvellous Moving Miocene Mouse Machine, 1981. Photographer unknown. (Photo courtesy ROM Photography).

not. The host, when this was mentioned, assured Francis that Loris was drinking milk only because he had an ulcer, but that he had laced it with whiskey, thereby obeying doctor's orders yet joining his colleagues. He always found his own way.

Several obituaries already have been written (Harington 1998; Shaul 1998; Sues 1998; Tokaryk 1998; Churcher 2003), and two appreciations (Swinton 1976; Churcher 1993), with many additional biographical details. Swinton (1976) also included a fairly complete Russell bibliography up to 1976. A more complete bibliography is included herein.

The Russell papers, including diaries, field notes, photos, films (several different kinds), correspondence and other records, were inventoried by Boden (1999) and Baltovich (2001), and are placed in the ROM archives. His slides and reprints of scientific articles are stored in the Section of Palaeobiology, Department of Natural History, ROM. Hopefully, someone in the future will take advantage of this material (particularly the diaries and films) and write a book on Loris Russell.

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Compiled by KEVIN L. SEYMOUR

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Book Reviews

ZOOLOGY

The Uses and Curation of Birds' Egg Collections: An Examination and Biography

By Martin Limbert. Peregrine Books, 27 Hunger Hills Avenue, Horsforth, Leeds, West Yorkshire LS18 5JS. Hardcover. 97 pages, £31 which includes postage to Canada if paid by postal money order.

This book was written largely to explain why egg collections should be preserved and to counter negative attitudes in Britain, where egg collecting has been illegal for half a century. Sadly, some museums have progressively removed birds' eggs from public display and consigned them instead to storage and, often, neglect. The need for and methods of careful preservation of surviving egg collections are discussed in some detail.

There is much here of historical interest. Systematic egg collecting in England dates back at least to 1662. Hewitson in 1831 coined the term, "oology." Overzealous collecting at times contributed to species' declines. Egg set data are valuable in mapping distribution limits of individual bird species, but errors in identification and outright fraud by some egg dealers mean that some cannot be accepted at face value; the Canadian example of Walter Raine is mentioned in this regard.

Limbert points out that nests and eggs have yet to be described for up to three thousand bird species in the world, and much information from extant collections has not yet been shared. Only recently, numerous egg collections were studied to analyse 12 000 clutches of the Common Cuckoo, thereby adding greatly to our understanding of the extent of variation in size and colour of cuckoo eggs deposited in the nests of different hosts. Phenologic investigation reveals the extent to which the eggs are laid earlier in warmer years. Eggs are occasionally useful in determining phylogenetic relationships of unusual species such as the Sandgrouse. Preserved contents of eggs can be saved for pesticide analysis. And, as modern ornithologists learned from Ratcliffe in 1962, egg-shell thinning has been an indicator of pesticide burdens and thus a method of monitoring the environment.

Of interest to many readers will be the gastronomic aspects of seabird egg-collecting on cliffs, especially the abundant and highly palatable egg of the Common Guillemot at Flamborough. Later, eggs from this guillemot colony became celebrated among oologists for their variety of marking and colour.

This book deals almost exclusively with oological matters – and oology publications – concerning Great Britain. Thirty-three valuable pages of bibliography are given, citing mainly European sources; the landmark American publications of Bent, Bendire and Reed are not included. Oology periodicals began forty years later in Britain than those in the United States, but ceased publication about the same time as the *Oologist,* the last survivor in America.

I detected one error in terminology, the use of "extinction" from one country of a species surviving elsewhere; he should have used "extirpation." This attractive, but expensive, little book is recommended to anyone interested in the British approach to past bird's egg collections.

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Birds of Nunavut: A Checklist

By James M. Richards, Y. Robert Tymstra, and Anthony W. White. Birders Journal, 701 Rossland Road East, Suite 393, Whitby, Ontario L1N 9K3 Canada 21 pages. Canadian $8. Paper plus $1.50 postage.

This attractive booklet lists 254 confirmed species, including 124 that are known to breed, plus 9 hypothetical species. Separate codes in columns give status codes for abundance and breeding for three arbitrary geographic subdivisions, "Mainland" (most but not all of the former territory of Keewatin), "Arctic Islands," and "Bay Islands" (south of sixty degrees). As evidence that birding knowledge of Nunavut is increasing rapidly, 48 confirmed species have been added during the three years immediately prior to publication. An excellent map is unusually helpful because it gives both the former English names and the Inuktitut names (new for most of us) for each settlement, many of which were initially Hudson's Bay Company fur trading posts. There are two pages of bibliography. All in all, this is a commendable work in progress, and the price is within easy reach.

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Birds of the Untamed West: The History of Birdlife in Nebraska, 1750 to 1875

By James E. Ducey. 2000. Making History, [but released for review in 2002]. 2415 N 56th Street, Omaha, Nebraska 68104 USA. 300 pages. U.S. $25.00. Paper.

This book is a valiant attempt to report the ornithological history of Nebraska to 1875. Commendable strengths include Chapter 1, which discusses the bird knowledge and lore of the native Americans, the Lakota, Missouria, Otoe, Omaha, Pawnee, Ponca, and Winnebago tribes. Native language bird names are provided when available. Chapter 2 provides a summary of historic explorations, most of which were made by men merely passing through the state while heading farther north and west. Many of these explorers came through in autumn, after the bird breeding season was over. Exceptions were Lewis and Clark, in Nebraska from 11 July to 8 September 1804, and Thomas Say with the Major Long expedition, present from 19 September 1819 to 6 June 1820. Chapter 3 provides a succinct account of the early bird habitats, and Chapter 4 tells which species were found in each of these habitats. Ducey provides, in square brackets, occasional corrections of obviously misleading statements in Aughey's 1877 paper. The list of references I found impressive. Thirty-three early illustrations add to the interest and attractiveness of the book.

For each observation, the name of the current Nebraska county is provided in upper case letters: "shouting" in modern computer parlance and to me a bit annoying. Unlike Robert E. Stewart's North Dakota book, Ducey does not provide a map showing the location of each county, forcing the reader to provide himself with a Nebraska state map before reading very far.

Before listing the shortcomings of Chapter 5, the last half of the book, I chose to use Myron Swenk's historical articles in *Nebraska Bird Review* (in the late 1930s) as a veracity check. I was not too surprised to find that Swenk had, in the late 1930s, provided more detail and better documentation than Ducey. If one takes the Lewis and Clark expedition as an example, Swenk used a not excessive seven pages, including a map showing the progress day by day, consulted original, primary sources, and gave more detail about extant diaries of several members of the expedition. As a further check, I compared the four-plus pages of Nebraska citations in Gollop's Eskimo Curlew monograph with Ducey's account, which again was less complete.

Chapter 5, a List of Species, occupies 110 pages; it lists excavated faunal remains from various forts and Indian camps, and is a useful compilation that leads the reader to original sources. Sadly, Ducey fails to place the verbatim accounts of each species in the explorer's words, indicated by quotation marks or a different font. As a result, one can rarely differentiate fact from Ducey's speculation, extrapolation, and "best guesses." His terminology and presentation are inconsistent, especially concerning whether an individual species is a migrant or a resident, and whether or not there is specific evidence of breeding. His use of "migratory species" is a less satisfactory term than "migrant." Far too often, the term "potential breeder" is used without evidence of dates or localities for eggs or young. Clearly, a conventional publishing house would have provided the outside editorial assistance that this book lacks. The index is incomplete.

In spite of my caveats, especially the idiosyncratic presentation of the species list, anyone interested in the history of ornithology in Nebraska will find much of interest in this inexpensive book.

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Birds of Nebraska: Their Distribution and Temporal Occurrence

By Roger S. Sharpe, W. Ross Silcock, and Joel G. Jorgensen. 2001. University of Nebraska Press, 233 North 8th Street, Lincoln, Nebraska 68588-0255 USA 520 pages. U.S. $69.95. Cloth.

This book is a nearly ideal state bird book, a scholarly compilation of sightings and specimens, with careful assessment of questionable sight and specimen records. Subspecies receive detailed and precise attention. There is helpful information about the best spots to search for each species. Good use is made of data from Breeding Bird Surveys and Christmas Bird Counts, but only sporadic use is made of banding recoveries. The price is kept low by omitting paintings of each bird species, a feature of more sumptuous state books. Four maps are useful for locating counties, but one must consult the Gazeteer (which fails to include Pine Ridge) to locate specific towns, parks, refuges and other geographic features.

The introduction deals with geography, geomorphology, aquatic systems, and climate, and then describes each of the main environments. The history of Nebraska ornithology is given in ten succinct pages, while another six tell how to use the species accounts, emphasizing the key importance of the Distribution and Ecology section for each species; sadly, the reader is not alerted to the list of abbreviations in Appendix 1.

As might be expected in such a book, there is a wealth of intriguing information, especially about range extensions and both increases and decreases in populations; commendably, the maximum number of individuals seen at one time is provided for most species. Other items that caught my attention were: Gray Partridge spread into Nebraska spontaneously from South Dakota and Iowa after much earlier attempts to introduce them directly had failed; most Ruffed Grouse disappeared by the 1880s, and it is now listed as an

extirpated species; a Clapper Rail caught in a mink trap in January was the farthest inland record, the nearest being Tennessee; several hundred Buff-breasted Sandpipers followed a farmer working a field; a Cliff Swallow colony contained 3700 nests. There is a useful warning about reliance on vocalizations to separate the Eastern from the Western Wood-Pewee. The authors also mention a population of chickadees in the Wildcat Hills that resembled Black-capped Chickadees morphologically, but sang Mountain Chickadee songs.

Regrettably, lower priority is given to nest records as compared to sightings, although the latter are of lesser biological importance. Only a relatively few species have data from the Cornell Nest Card Program, with detailed numbers and dates of nests. For some other breeding species, dates and localities of nests, eggs or flightless young are not provided; we can only guess that in some cases they were not available, but surely for at least the Mourning Dove and Yellow-headed Blackbird they were simply omitted. No list of host species for Nebraska is provided for the Brown-headed Cowbird.

It would have been helpful to place unaccepted records within square brackets and add abbreviations for journals at the top of the list of references. The subspecies account for the Great Horned Owl is incorrect since the wapacuthu race of the Great Horned Owl has been discredited. The account of the Poorwill is misleading, implying that the Flint Hills are in Nebraska, whereas they are in Kansas. Mention is made of a Golden Eagle nest with four young without comment that this may be the first such record in the North American literature, though observations of two Golden Eagle nests with four eggs have been published previously.

My minor criticisms aside, this is an excellent summary of what is known about Nebraska birds. The state is important for the number of its bird species (415 with a specimen or recognizable photograph, 13 with a description acceptable to the state committee, and 5 extinct or extirpated), and because it is the meeting place for many closely related species which overlap in range and sometimes interbreed. Birds of Nebraska is a substantial and welcome addition to ornithology in general and to state bird books in particular.

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863 University Drive, Saskatoon, Saskatchewan S7N 0J8 Canada

Canadian Skin and Scales: A Complete Encyclopedia of Canadian Amphibians and Reptiles

By Pat E. Bumstead. Illustrated by Norman H. Worsley. 2003. Simply Wild Publications Inc., 100 Lake Lucerne Close SE, Calgary. Alberta T2J 3H8 Canada 161 pages. $24.95.

Although subtitled "a complete encyclopedia" this book obviously was never intended to be so pretentious, but instead to serve young naturalists' as a "first book". The cover, with bright colour photos of a Horned Lizard (Stephen Glendining), Plains Garter Snake, Western Painted Turtle, Northern Leopard Frog, and Tiger Salamander (Brian Woltski), will attract them. Any suspected western bias is soon dispelled by the content, which is spread evenly across Canada. Black-and-white sketches by Norman H. Worsley depict all Canadian species and a selection of extra-limital representatives of families. Many are adequate, some good, but others are barely recognizable (e.g., the wrinkled Spotted Salamander on page 25 and Black Rat Snake on page 124), and one is clearly the wrong selection (the Ensatina on page 32 of a southern pattern not occurring in Canada).

The pedagogical style begins with "Canadian Creatures", covering communal activities, wintering, being dark, food resources and hibernating sites, and advantages for those reptiles bearing young (in Canada, two lizards and 13 snakes) rather than laying eggs. Province-by-province species lists follow. Chapters 2-9 deal with amphibians in general, salamanders and newts (21 species), frogs and toads (25), reptiles in general, turtles and tortoises (14), lizards (5), and snakes (24). Each family and each species which occurs in Canada is an individual account. Those for families give world and Canadian species totals, world range, characteristics, and reproduction. The species accounts include common and scientific name, a paragraph of introduction, colour, reproduction, "where do they live" (habitat and provinces), and a "did you know" section. A series of questions with reference to the page where an answer can be found are at the bottom of many of the pages in this section. Chapter 9 deals with Conservation and includes definitions for status categories and species thought to be extirpated in Canada (Timber Rattlesnake, Pacific Pond Turtle, Pygmy Horned Lizard, Pacific Gopher Snake, Eastern Tiger Salamander). Nine threats to others are listed from habitat loss to introduction of exotic species. A "you can help" section presents ideas for group and individual participation. A final chapter, "Etcetera", covers diagrams of forms and features, the availability of a teachers guide, and a list of Canadian internet wildlife links, words to know, published and internet resources used, and a five-page index. Finally, there is a note from the author and a short biography of the illustrator.

Although primarily concerned with Canada, the text erratically adds extra-limital filler statements such as that Mudpuppies "have been introduced in large New England rivers" or that Western Skinks have been found on islands off the coast of California. For the geographically challenged it is not made clear that species listed for "Newfoundland" are those for the political entity

that includes mainland Labrador (accounting for the salamanders included), or that the generally arctic Nunavut extends south to include islands in Hudson Bay (accounting for the occurrence of a frog and a toad in the territory).

The foreword, an endorsement by Carolyn and David Seburn, rightly extols the book for its overriding themes of excitement in observing amphibians and reptiles, the need to treat them with respect, and the importance of conserving their habitats. But they overlook, or were unaware of, problems precipitated by generalizations and simplifications while copying information from the literature apparently without personal experience with many forms. Particularly misleading in all frog and toad accounts is that the number of eggs is followed by an "adults appear" which actually refers to when tadpoles transform, the resulting froglets are not "adults" (mature) for months or another year or more later. For all toads, spadefoots, and treefrogs only the aquatic habitats where they breed are given under "where they live" whereas most are terrestrial much of the year. Unfortunately, such "information" is as easily absorbed by the unwary and uncritical beginner as fact, and detracts from the otherwise commendable concept and aim of the effort.

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Conservation and Ecology of Turtles of the Mid-Atlantic Region: A Symposium

Edited by Christopher W. Swarth, Willem M. Roosenburg and Erik Kiviat. 2004. Bibliomania! books@bibliomania.com. 122 pages. U.S. $22.50.

The Mid-Atlantic region of the USA (from Virginia to New York) is an area of exceptional turtle diversity, with 22 species (including four sea turtles). It is also an area under exceptional development pressure. A two-day conference was organized to discuss the status and ecology of the species affected and held in October 1999.

This volume brings together 11 peer-reviewed papers and 18 abstracts from the conference. The book begins with an introduction by the editors and the text of a keynote address by Michael Klemens, who briefly summarizes the conclusions from his book *Turtle Conservation* (2000; Smithsonian Institution Press). The papers cover only six of the possible species occurring in the area, with three papers on each of the Diamondback Terrapin and the Box Turtle, two on the Red-bellied Turtle and one each on the Blanding's Turtle, Bog Turtle, and Spotted Turtle. The papers cover a wide range of topics including nest predation, head-starting, habitat change detection, and population ecology. Although the papers are peer-reviewed, they are of varying quality. One of the papers is barely more than a page in length and is little more than a report on the number of turtles caught at one site. From a conservation perspective, the most interesting paper is by Erik Kiviat (one of the editors) and various collaborators and deals with the response of Blanding's Turtles to wetland and upland habitat creation as part of a wetland mitigation project. Although the results are still preliminary (three years) Blanding's Turtles made use of constructed nesting sites and wetlands. It is interesting, however, that the turtles did not choose to overwinter in constructed wetlands.

This collection is not the definitive statement on the conservation of turtles in the eastern U.S. There are no papers (although some abstracts) on many topics, such as traffic mortality, or the effects of toxins, or genetic isolation. Nonetheless, it is a valuable snapshot of the wide range of activities being undertaken and it will be of interest to anyone involved in turtle conservation.

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For Love of Insects

By Thomas Eisner. 2003. The Belknap Press of Harvard University Press. Cambridge, Massachusetts, and London, England. 464 pages. U.S. $29.95. Cloth.

Thomas Eisner is an entomological legend. His photo, on the dust jacket of this fine book, shows a middle-aged man cockily riding his bicycle, seated backward on the handle bars. Eisner is to entomology what Richard Feynman was to physics — brilliant, quirky, and full of good stories. If, for some reason, you need to be convinced of the fact that insects are among the most amazing creatures on earth, this is the book for you.

The preface to this book of insect tales compares Thomas Eisner to Jean-Henri Fabre, the pioneer writer on insect behaviour, who lived in the 19th century in the south of France. E. O. Wilson, the preface's author, seems comfortable with this comparison, but to me they are two very different sorts of scientists. Fabre was a poor man, and a loner. His observations were conducted with no institutional support, and his genius (Darwin called him "the incomparable observer") was not recognized until Fabre was a very old man. Eisner, by contrast, is a hot-shot researcher at the top of his game, at what is probably the finest university for insect studies in North America (Cornell, in Ithaca, New York), surrounded by cooperative peers, graduate students, and lots of grant money. While Fabre's stories tell of hardship and isolation, Eisner's explore the life of a modern biologist in the publish-or-perish world of research science. (Publishing, by the way,

seems to come as easily to Eisner as sneezing comes to most of the rest of us.)

The greatest thing about Eisner, however, is that he keeps the passion alive, and dwells not on the institutional politics of science, but on his life-long fascination with the creatures that he studies. Eisner is a chemical ecologist, and thus the book is largely about insects and the chemicals they produce. But don't get the impression that it is technically difficult to understand. It begins with a chapter on bombardier beetles, and the amazing way that they spray boiling quinines out their butts, and direct them accurately into the faces of their enemies. This chapter, like the others, does a nifty little dance between the insects and their adaptations on the one hand, and the process of scientific discovery on the other. The rest of the book is just as spellbinding, and in it the reader is treated to such juicy tidbits as explanations of how living things can defend themselves with cyanide without accidentally committing suicide, along with a host of other marvelous insect adaptations, all skilfully elucidated by Eisner, his colleagues, and his students. The chapter on spider webs is wonderful. And if you think you understand insects and mimicry, this book will surely expose you to vast unexpected dimensions to this supposedly simple phenomenon.

Thomas Eisner is also a superb photographer, and one of the other great strengths of this book lies in the pictures. He also uses clever illustrations to make his point, and is clearly the sort of person who is good at entertaining his undergraduate students while he teaches. All of this comes together masterfully, to create a very fine book indeed. Do I have any criticisms? Not really, although for a book about "insects" it contains a wealth of information on arachnids as well. I suppose Eisner and his publisher didn't want to use the term "arthropods," or the term "bugs" to get around this perennial problem. No—this is a superb book, and a book that naturalists at all levels will enjoy. At the weekly entomology luncheon at the University of Alberta, I found that many of my senior colleagues (very well-read and enthusiastic entomologists!) were amazed by how much they learned from "For Love of Insects." I enthusiastically agree, and recommend it heartily.

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The Freshwater Fishes of Manitoba

By Kenneth W. Stewart and Douglas A. Watkinson. 2004. University of Manitoba Press, 301 St. John's College, University of Manitoba, Winnipeg, Manitoba, R3T 2M5. xvii + 276 pages. $29.95. Paper.

This book is a delight to read and use. The layout is innovative and the text is in an exceptionally clear font and is well written. The book is dedicated to the late Dr. Ed J. Crossman of the Royal Ontario Museum and co-author of the book *Freshwater Fishes of Canada.*

The freshwater fishes of Manitoba comprise 79 native species, 1 re-introduced species after extirpation, 10 introduced species, 2 artificial hybrids and 4 estuarine species from the Hudson Bay coast. This is the third most diverse ichthyofauna in Canada after Ontario and Quebec. Fifteen species from waters outside, but neighbouring Manitoba, are included as they may eventually be discovered in the province. There are various introductory sections such as biogeography, geography, species diversity patterns, and summary sections like a glossary and a checklist, usually found in fish books. There is also an appendix which summarises fish distributions by watershed and a list of references. There is no index but the unique layout assists in navigating the pages.

The presentation of the book is very attractive and easy to use. Each family account with its species has a unique colour which appears in text headings, scientific and common names here and in tables elsewhere, and along the upper half of the outer page margin (outlining the English and French names) which allows rapid flipping as a search mechanism. It is immediately obvious when one moves from one family to another in the text and quick searches for a particular group are facilitated. The scientific and English family name is at the top right and left of each page and also allows rapid flip searches.

The series of habitat photographs in the geography section are excellent, and have descriptive comments. One, showing the lower Churchill River could be almost anywhere in the vast boreal forest except for that peculiar hazard to Manitoban freshwater ichthyologists, a Polar Bear paddling by.

Each species account gives the English, French and scientific names, a colour photograph of the fish, a section on Identification with key characters in bold (sometimes only a single, short sentence for distinctive species), a Distribution in Manitoba, Biological Notes including spawning, growth and adult size, feeding, habitat, and ecological role, and Importance to People. The latter refers to commercial, angling, ecological and conservation importance. There is no lengthy anatomical description of the species as is seen in most fish books, characters being restricted to those used in identification with some explanation of colour variations and amplification of characters from the Keys.

All the fish illustrations are ideally positioned in the species description rather than grouped as colour plates. These photographs are generally excellent, although some key characters such as mouth parts are not evident and a close-up photograph of them would have added to the reader's understanding.

The distribution of fishes on the maps is very clear. Red spots show known occurrences, black spots introductions while grey shading shows the continuous range of native species. The grey shading generally conforms to distributions based on the red spots, filling in the gaps. However in a number of species, the limits of grey shading conform neither to the red spots nor obviously to drainage basins. There is no explanation of how this overall distribution was arrived at but is presumably related to ecological limits for the species and physical barriers. Some form of shading to fill in lakes would have made the background map clearer and perhaps partially address the previous comment.

Identification keys for each family are found at the beginning of each family account. An alternative arrangement is to group all keys together and this is one many field and laboratory biologists would prefer. Fish are wet and slimy and having keys grouped together makes for less page turning or facilitates xeroxing and annotating. The keys work well although the one for distinguishing the Brown and Black bullheads gives diagrams of the supraethmoid shapes without explaining what or where this structure is (and it is not in the Glossary either).

Some other minor points of criticism and comment must be noted. The scientific names lack the author and date, perhaps not of significance to most readers but a nuisance to find for those not familiar with the ichthyological literature. The copy I have lacks paper covers and there is only the briefest of blurbs on the authors whose names are sufficiently common not to lend themselves to easy Googling – more background on the authors is often of interest to readers. The common names of fishes in English and French are on the margin of each page enabling a rapid flip through as a search. However the scientific name is not there (and there is space to add it) which would have been a great convenience. It is necessary to remember to flip back to front as well as front to back since some species are only on one page; this is inescapable in the design. The key to Cottidae is a little confusing as "Key to the freshwater sculpins and marine sculpins of the genus *Myoxocephalus*" as this can be read as being a key to only *Myoxocephalus* species although *Cottus* species and freshwater *Myoxocephalus* are included. The photographs note whether a specimen is fresh or preserved but readers should be warned that preserved here generally means very recent preservation as colour is still retained – museum specimens of any age soon lose the colour; compare the colourful "preserved" northern redbelly dace with the really preserved and brownish deepwater sculpin. A few photographs are not as revealing as one could hope for, the colourful sticklebacks being poorly served in this respect. The Glossary is good, distinguishing such terms as bar, band and stripe although commensial is more commonly spelled commensal and watershed is not a "water body together with all its tributaries" but strictly "an elevated boundary area separating tributaries draining to different river systems", and the subopercular bone does not lie completely above the interopercular but mainly behind it (see www.briancoad.com).

Although books on fishes do tend to separate into those on marine species and those in fresh waters, the Manitoban coastal fauna on Hudson Bay comprises only 27 species (Coad and Reist 2004) and could have been included in the book. The authors do in fact deal with 13 of these species which are found in estuarine and fresh waters also. So another 14 species would have given a complete treatment of the Manitoban fishes.

This book will long stand as the definitive guide to Manitoban freshwater fishes and sets a standard for all subsequent provincial and national books of fish faunas.

Literature Cited

Coad, B. W., and **Reist, J. D.** 2004. Annotated List of the Arctic Marine Fishes of Canada. Canadian Manuscript Report of Fisheries and Aquatic Sciences, 2674: iv + 112 pages.

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The History of Ornithology in Virginia

By David W. Johnston. 2003. The University of Virginia Press, Box 400318, Charlottesville, Virginia 22904-4318 USA. 219 pages. $35.00 U.S. Cloth.

True to the promise implicit in his title, David Johnston's book is a thorough history of ornithology in Virginia. The first five chapters take us from the Tertiary period 65 million years ago through to an examination of 19th-century reports and collections. Along the way we learn all manner of interesting facts. The abundance of skeletal elements of the extinct Passenger Pigeon show it to have been common in the late Pleistocene over 12,000 years ago, and Rock Ptarmigan, Spruce Grouse and Gray Jay remains indicate a cooler climate at the time. Archaeological research at a 1700-year-old Indian midden provided the state's only record of the Ivory-billed Woodpecker. Around 1650, early English settlers were so hungry that at times they ate bluebirds, larks, cardinals and goldfinches – and Carolina Parakeets – as well as waterfowl, shorebirds, and upland game birds. When settlers arrived from England about 1590, the Indians were cutting holes in gourds to entice Purple Martins to nest.

The chapters on early observers and naturalists are particularly interesting. Thomas Hariot, a young man selected by Sir Walter Raleigh to be part of the 1585 expedition and settlement, made one of the first attempts to list North American birds, but Johnston tells us that Hariot's list of 111 species has never been found. Fortunately, the paintings of John White, Har-

iot's fellow expedition member and grandfather of Virginia Dare (the first English child born in America), have survived. White painted 35 species of birds and gave the Algonquian name for 23 of them.

The first naturalists in Virginia were the clergyman and botanist, John Banister, who lived at Bristol Parish from 1678 until he was accidentally killed in 1692, and the Reverend John Clayton (1657-1725), who published information about birds and weather in the world's first scientific journal, Philosophical Transactions of the Royal Society of London; four pages of Clayton's account are reproduced by Johnston. Sadly, although Mark Catesby spent seven years in Virginia, 1712-1719, he was then a botanical collector who had not yet learned to paint birds; from those years he mentioned only 33 bird species. When he returned later for another six years, Catesby spent his time farther south, so that his famous book deals mainly with the Carolinas and rarely makes specific mention of Virginia. In 1787, Thomas Jefferson, 14 years before he became the third president of the United States, made the first attempt to list all the birds of Virginia, adding 34 additional species to the 100 pictured for adjacent regions by Catesby.

Later chapters deal specifically with topics such as the contributions of ornithologists with the Smithsonian Institution and the United States government; conservation and game laws; artist-naturalists; extirpated and introduced bird species; falconry; and regions of ornithological importance describing the observers and the contributions for each. Many famous naturalists worked in or passed through Virginia, among them John James Audubon and Roger Tory Peterson. Peterson, while stationed with the U.S. army at Fort Belvoir, "successfully petitioned the officer-in-charge to reroute the line of march on the drill field to avoid an occupied Horned Lark's nest" (page 121).

Items deserving special commendation are the detailed lists: principal ornithological accomplishments; type specimens from Virginia; local bird lists, 1870-1926; recent bird lists since 1952; Virginia nature writing, 1817-1998; books since 1965 that mention Virginia's avifauna; Algonquian Indian names of birds; bird banders, 1923-1965; principal collectors of bird specimens; and observers reporting migration records to the U.S. Biological Survey, 1884-1946. Detailed references throughout and a selection of old drawings and more recent photographs add to the interest.

Johnston's scholarly and painstaking research makes this is one of the finest ornithological histories available for any state. There are some weaknesses, such as the lack of a Virginia map and an incomplete and inconsistent index which omits names of some important people. This book is a necessity in every museum and University library in North America, and for any one with an interest in the history of ornithology.

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All-Weather Hawk Watcher's Field Journal

By Donald Heintzelman. J. L. Darling Corp. 2614 Pacific Hwy., Tacoma, Washington 98424-1017 USA. 66 pages. U.S. $7.95 Paper

This handy pocket field notebook, 12 by 17.5 cm., consists of a conservation note, a one-page introduction, a three-page list of the diurnal birds of prey of North and Central America, and 51 pages for field observations. At the top of each page are blanks to fill in for date, time, weather, and location, including GPS coordinates. The special feature is the use of all-weather writing paper so that one can write in the rain!

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Self-Portrait With Turtles: A Memoir

By David Carroll. 2004. Houghton Mifflin, 222 Berkeley Street, Boston, Massachusetts USA. 181 pages. U.S. $23.

David Carroll first saw a Spotted Turtle at the age of eight. He has been enchanted by these amazing creatures ever since.

In this exquisitely written book the author of *The Year of the Turtle* and *Swampwalker's Journal* shares his obsession with turtles, nature and art. This basically chronological book is divided into four sections: Early Years, Art School, Middle Years, Later Years. Through these sections we see the development of a consummate naturalist and artist, witness his choice of art school over science and the growth of his teaching and artistic careers. The book concludes with Carroll hunting for turtles on the 50^{th} anniversary of his first discovery of a Spotted Turtle.

Carroll's memoir overcomes the common pitfall of bogging down in autobiographical trivia. His writing is compelling and thought-provoking: "Consecrated to the God of my parents before my eyes were open, I lived my first eight years in a closed circle of family, relatives, church, and school. I lived in a totally human environment filled with human concerns and considerations. It was a world built by people for people." And yet within three days of his family moving to a new home, Carroll had discovered a wetland and encountered a Spotted Turtle: "With that first turtle I crossed a boundary of greater dimensions than I can ever fully comprehend. I changed lives within a life, worlds within a world."

Although Carroll's passion is turtles, his deep connection with nature will resonate with any avid natu-

ralist. His writing is honest and moving in its evocation of special places and moments as well as the loss of many of those special places over time: "My long history with turtles has been marked time and again by loss of place, by the physical and spiritual annihilation of the landscape, compelling me to move on in search of wilder places."

This is also the kind of book you can give to non-naturalist friends to try to make them understand why you love wading through swamps. Its combination of graceful writing, compelling anecdotes and Carroll's own beautiful black and white illustrations are enough to enchant almost any intelligent reader.

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Wild Mammals of North America: Biology, Management, and Conservation (Second edition)

Edited by George A. Feldhamer, Bruce C. Thompson, and Joseph A. Chapman. 2003. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363 USA. xiii + 1216 pages. U.S. $175. Cloth.

After a 21 year interlude, the update of this monumental volume on the biology and management of North American mammals has added a third editor and given a more prominent role to conservation as opposed to economic importance. Even with a larger page format and a reduction of two chapters, the second edition is longer than the first, which reflects the accumulated increase in research over the past two decades. All of the accounts are updated to various degrees with some references as recent as the same year of publication (2003) of this book. A completely new set of authors has been recruited to write half (28) of the 55 chapters. Only six chapters have retained the original contributors and these are all single authored accounts. However, three of these accounts (black bear, badger, and manatee) are negligibly changed from the first edition. Of the 102 authors, there are three who have contributed to two chapters.

The species coverage of this revised volume has been slightly modified. There are new accounts for *Cynomys ludovicianus* (Black-tailed Prairie Dog) and *Neotoma floridana* (Eastern Woodrat) but the invasive *Rattus norvegicus* (Brown Rat) has been removed and the species of foxes, *Martes*, and skunks that were each previously presented in two chapters have each been combined. Furthermore, three chapters have been expanded including the addition of *Macrotus californicus* (California Leaf-nosed Bat) to the bats, *Ammospermophilus* (antelope ground squirrel) to the ground squirrels, and the subsuming of *Cervus nippon* (Sika Deer) into a more inclusive non-native large mammals category covering several species at the end of the book. Recent taxonomy also has been incorporated such as the generic use of *Lontra* for the river otter, *Puma* for the Mountain Lion, and *Tayassu* for the Collared Peccary.

Of the over 400 species of mammals known from North America, approximately half (210) are covered but 155 of these species are not full accounts. The chapters range from 28 detailed single-species accounts to six chapters that focus on two species with multi-taxa reports comprising the remainder. Some of these latter chapters concentrate on higher taxonomic groups including the six species of voles (genus *Microtus*) found in North America; two genera of ground squirrels (*Spermophilus* and *Ammospermophilus*) covering 25 species; six species of foxes in the genera *Alopex, Urocyon* and *Vulpes*; 19 species of pocket gophers in the family Geomyidae; six species of bats from the Vespertilionidae family, one species from Molossidae, and one species from Phyllostomidae; six species representing the toothed whale suborder Odontoceti; and 11 species of the baleen whale suborder Mysticeti. The final chapter treats several exotic or alien species and their associated problems as related to the native fauna.

The general format within each account essentially has remained the same as the first edition. Chapters begin by reviewing the nomenclature, distribution, and description of the species or species-group. Most accounts include life history topics such as physiology, reproduction, age estimation, ecology, feeding habits, behavior, and mortality. A summary is then presented on the economic status, management, conservation, and research needs of the taxa under study. Other subjects covered by some but not all accounts are genetics, anatomy, development and habitat. Except for the last chapter, all have distribution maps, skull figures, and most have photographs of live animals. The book ends with two appendices identifying cranial bones and illustrating standard cranial measurements, a glossary, and an index.

With over 100 contributors to this edited book on wild mammal species deemed to have management significance in North America, it was inevitable that there would be inconsistent treatment across groups. For example, the account of the Black Bear (*Ursus americanus*) is one of the shortest chapters although it is a relatively well-studied and endangered mammal that is in need of a comprehensive management programme. There is almost no mention of its conservation status or of its economic importance, and the chapter is not much changed from the first edition. In contrast, the longest single-species account is for the Bison (*Bison bison*), a highly managed species with very few free-ranging individuals. The text has been substantially revised from the original account and is one of the more thoroughly covered species. Within the multi-taxa chapters, the presentation of information was not standardized, making it difficult to locate specific information for comparative purposes. For example, the seals began with general characteristics for pinnipeds

and then finished with individual accounts for the 16 different species. In contrast, toothed whales included three detailed and sequential species accounts followed by abbreviated discussions on three other species.

Overall, this revised edition contains some of the most comprehensive descriptions of mammal species found in North America. Notwithstanding the aforementioned criticisms, the editors have continued the fine tradition of thoroughness and scholarship established in their first volume. Not only are the accounts a summary of our biological knowledge of the larger species but the information also is interpreted and presented in the context of management and conservation. This book will be the primary reference source that bridges the gap between applied biology and policy implementation. A companion volume dealing with the small mammals, and the other half of mammalian diversity, in North America would be a nice complement but perhaps wishful thinking for others to undertake. One noticeable drawback is that the publication is expensive, which will discourage students, researchers, and government workers from purchasing it for their personal library. This book, however, is a required monograph for institutional and departmental libraries that have an interest in not only mammals and their conservation or management but also wildlife ecology, in general.

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Pete Dunne on Bird Watching: The How-to, Where-to and When-to of Birding

By Peter Dunne. 2003. Houghton Mifflin, 222 Berkeley Street, Boston, Massachusetts 02116. USA. 352 pages. U.S. $12.

Birdwatching is one of the fastest growing outdoor activities in North America. Once the obsession of a few, it is now firmly lodged in the mainstream. Bird books have proliferated, the optical equipment gets better every year, and birding clubs and media are now commonplace: there are even television shows about birding. With all these riches, what is a novice to do? Pete Dunne's latest work is a good place to start. With this cleverly thought out book, Pete Dunne starts at the beginning and provides the tools and tips to make birding a lifelong journey of discovery.

The author is a gifted communicator and teacher, making the material accessible and a fun read, while at the same time packing dozens of tools and tips into three hundred information-filled pages. The place he starts is the backyard – precisely the place where many people first get hooked on birds. He then walks the reader through the tools of the trade, the fundamentals of birding, applied birding ("for fun, purpose… even profit!"), eventually bringing the reader full circle to ethics and a solid conclusion that reminds us of why we birdwatch. Each chapter ends with a useful summary of key learning objectives, which helps to hammer home the important points. He keeps the material alive by interspersing anecdotes from his own rich experience, and others gleaned from a veritable who's who of North American birding. There are plenty of photos (black-and-white, this is no coffee table book) to illustrate points the author wants to make. The author's dry wit frequently surfaces, so be prepared for the occasional good laugh.

Some of the advice is priceless, particularly ten key questions to ask when identifying a bird, and a section entitled "learning to see." This is complemented by practical advice on things like how to pick binoculars, field guides and spotting scopes. For example, the author provides a helpful hint on how to check to see if that great pair of binoculars you are thinking of buying is in alignment; if they are not, your eyes will suffer.

There is also plenty of advice – generic and specific – on "where to go" and how to maximize your birding once you get there (my favorite: "the power of the pause", wait, and birds will show up). He also talks about how to contribute to the store of knowledge while having good fun, for example by participating on Christmas Counts and Breeding Bird Atlases. In the final chapters the author notches the level up several grades, letting novice birders in on some of the inner secrets of successful birders like how to be where and when the birds are. He even divulges the secret of the perfect Eastern Screech Owl imitation (I'm not telling, you will have to read the book to find out.)

Are there things I do not like about this book? Not many, but there are a few. The format, with plenty of inserts, is occasionally disconcerting, particularly some of the "insider's insights" with sometimes abrupt shifts from the author's voice to another, in one case into a lecturing tone thankfully absent in the rest of the book. Sometimes the order of things is confusing, for example the discussion on spotting scopes is widely separated from that on binoculars. While this follows a logical sequence (most birders start with binoculars and only "graduate" to scopes later on in their birding careers) is does seem misplaced. The advice provided is solid and if followed will make for better birders, but there are a few minor missteps. For example, the author perpetuates the oft-repeated myth that European birds are less responsive to squeaking than those in North America – not true in my experience. The book is also unabashedly North American centric; there is very little here about the rest of the world. Occasionally the book drifts towards the advertorial, for example a limited number of bird tour companies are highlighted, but generally the author strikes the right balance. There is one point in the book that I objected

to, and that was the description of the author, in a line with a dozen other birders, wading through a long grass prairie in an attempt to flush a Baird's Sparrow. While this anecdote was properly set in a discussion of ethics (he stepped on a grouse nest) the action described was out of character with the rest of the book (or even the advice provided in the rest of the book) and the ethical dimensions could have been more forcefully argued. These points do not seriously detract from the book, and I would rank it among the best birding "how-to" books I have encountered.

This book is aimed at the novice. If you have just started birding, this book is for you. If you know someone who has just started, this book would make a great gift. You may even want to lend it to your spouse, friends or relatives; anyone who is trying to figure out what all the fuss is about. Better still: donate it to the local school library after you are done with it. Will there be more to learn after you put this book down? Absolutely, but that is the whole point of the book: birding is a lifelong discovery.

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BOTANY

Alpine Plants of North America: An Encyclopaedia of Mountain Flowers from the Rockies to Alaska

By Graham Nicholls and Rick Lupp, Consulting Editor. 2003. Timber Press, 133 SW 2nd Avenue, Ste. 450, Portland, Oregon 97204 USA. 344 pages. U.S. $49.95. Cloth.

Entitled *Alpine Plants of North America*, this 344 page book takes an all-embracing look at many of nature's floral delights, which the author explains as being categorized as alpines, though they may be found anywhere from seaside to high mountain. Mr. Nicholls wins my applause by telling us that he likes to limit his plants to 30 cm (12 inches) in height, which I find keeps plants in scale in an average home rock garden.

The title might be a bit amusing to a Canadian – it appears to have been accomplished by excluding any plant references to land we hold dear! We are told the book is intended for practical, on site use, both in the field and in an owner's garden – generally Graham has succeeded but he falters a bit in the area of plant identification – something which is vital to enthusiastic alpine plant lovers. May I suggest that a few less species photographs and more emphasis on their clarity (there were a number of photos from which identification would be difficult if not impossible). More close-ups of flowers and foliage would help a great deal.

I thought that the format of the book was excellent: information on plants' natural growing areas and cultural tips made for a most helpful package of useful information. Choosing the best location and growing medium for our newest acquisitions is very often a painful experience. Having several identical plants and plenty of spare sites is sometimes our best hope of success. However, a careful reading of the needs of each species covered in this book should save many early plant funerals!

The introduction of little known species is great fun and I applaud Mr. Nicholls's inclusion of Talimums in his writing. I have only one species in my collection to date – *T. selinoides* – but after seeing photos of such beauties as *T. brevifolium*, and *T.* 'Zoe', I shall be very soon searching for more. It is most amazing to observe the miniature size, quantity and length of blooming period in this enjoyable plant.

It is refreshing to find a proven plantsman willing to share his knowledge of plant propagation so freely. This is most evident in his detailed directions concerning the taking of cuttings from various species of Phlox. Perhaps his most helpful writings in this area are the descriptions of each species' natural surroundings, soil conditions, and moisture tolerance. The book entices the reader to find suppliers of seeds, plants, or best of all to follow in Graham Nicholls' footsteps – to see at first hand the alpine specimens he has so carefully covered.

Both author Graham Nicholls and consulting editor Rick Lupp have done a magnificent job in producing a book of much needed information about the identification and growing of alpines and done it in a neat, readable, and orderly fashion. This book will give the reader true value for his or her money.

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Arboretum America, A Philosophy of the Forest

By Diana Beresford-Kroeger. 2003. University of Michigan Press, 839 Greene Street, Ann Arbor, Michigan 48104-3209 USA. 196 pages. U.S. $29.00.

Arboretum America, A Philosophy of the Forest is a unique work. It's a book about trees in a compound context – global, local and personal – informed by an intriguing variety of perspectives, including ecology, ethnobotany, horticulture, ethnology and mythology. The result is an eclectic and appealing book, no great surprise considering that the author, Canadian Diana Beresford-Kroeger, is, according to the back cover, a "botanist, medical and agricultural researcher, lecturer and self-defined "renegade scientist" in the fields of

classical botany, medical biochemistry, organic chemistry and nuclear chemistry."

The book starts with an introduction that includes appealing stories from Beresford-Kroeger's childhood, a discussion of the world as a global garden, a definition of Beresford-Kroeger's concept of "bioplanning"(covered in her previous book *Bioplanning a North Temperate Garden*), and a description of how bioplanning applies to forests. She then goes on to profile 20 North American tree groupings, including – genus followed by common name – *Acer* (Maple), *Asimina triloba* (Pawpaw), *Betula* (Birch), *Carya* (Hickory), *Catalpa* (Catalpa), *Crataegus* (Hawthorn), *Fraxinus* (Ash), *Gleditsia* (Honey Locus), *Juglans nigra* (Black Walnut), *Magnolia acuminata* (Cucumber Tree), *Ostrya virginiana* (Hop Hornbeam), *Pinus* (Pine), *Ptelea trifoliata* (Wafer Ash), *Quercus* (Oak), *Sambucus* (Elderberry), *Sassafras* (Sassafras), *Thuja occidentalis* (Cedar), *Tilia* (Basswood), *Tsuga* (Hemlock), *Ulmus* (Elm).

It's puzzling, this choice of trees. Why these groupings and not others? Why include elderberries and leave out dogwoods, why hemlocks and not firs, why birches and not aspens? The author never tells us why; never explains her inclusion and exclusion criteria. And I can't help but wonder, as I wander the fields and forests of home, about the cherries and beeches, tamaracks and spruces … should they not be included in forest bioplanning too?

That little grievance aside, the book is vibrant and delightful, with much to teach from the wide range of perspectives mentioned earlier. Each profile includes six sections: "The Global Garden", tracing the history and geography of each tree grouping; "Organic Care", covering related horticultural topics; "Medicine", discussing traditional and potential medicinal uses; "Ecofunction", describing the trees' ecological roles; "Bioplan", explaining how the trees have been and could continue to be incorporated into human environments; and "Design", about the trees' appearances and aesthetic properties.

Much of the information was new to me. Like a maple biochemical, acerin, currently being investigated for antiviral and antibiotic qualities. Like the birch being one of the two sacred trees given to the Aboriginal peoples of North America. Like pines contributing numerous important air-freshening compounds to the atmosphere. Like hawthorn fruit being called a "pome" which, along with the leaves, produces a number of biochemicals which form a high-energy compound beneficial to migrating birds. Like basswoods producing huge crops of nectar at a time when bees need it desperately and many other flowering plants have stopped blooming.

The profiles are interspersed with photographs of other members of the forest community – lichens, fungi, flowering plants, shrubs – which help enhance the bioplanning concept and paint a larger picture of the forest ecosystem. And the occasional yellow boxes with relevant stories from the author's life add a pleasing personal touch.

One of the most personal touches in the book appears at the end of the introduction, where Beresford-Kroeger shares with us her dream "that a moratorium will be put on the cutting of what is left of the global forests and that ordinary people with an acorn and a shovel begin the long road back to nature." Ordinary people. That's me. Though I don't know if I have any acorns around. But there's a collection of shovels in the garden shed, and space along the fence. Perhaps I could manage to find a handful of maple keys …

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Cape Cod Wildflowers: A Vanishing Heritage

By Mario J. DiGregorio and Jeff Wallner. 2003. University Press of New England, One Court Street, Lebanon, New Hampshire 03766 USA. 169 pages. U.S. $19.95.

This is a reprint of the original volume first published in 1989 by Mountain Press Publishing Company, with a new introduction by the authors. As the authors state, "This book is an appreciation, a guide, and a plea for protection. On one hand it explores the arcane lore of the medieval herbalists… On the other, it chronicles the latest scientific understanding of flowers' ecological importance and current attempts to preserve natural diversity."

If not unique, this book is at least one of very few examples of this particular approach to botanical description. It is arranged in chapters based upon habitat types, all common to the Cape Cod area. Each habitat is described in the opening of its chapter. The habitats include woodlands; ponds and bogs; sandplains; salt marshes; and dunes and beaches, with an additional chapter to accommodate alien species.

Each habitat type is represented by ten to fifteen species endemic to each area. As the authors admit, the sampling is limited in scope, covering only 66 of the 1300 species of vascular plants found in the Cape Cod area. Each species is covered on facing pages, with the left-hand page containing a description of the plant and other comments on such aspects as propagation and threats to its environment. A colour photograph of the flower is located on the right hand page.

The authors could have, however, spent a little more time in researching their data, especially since this is the second edition of their work. The pollination process of *Cypripedium acaule*, for instance, suffers from the following extremely fanciful and highly inaccurate description. "Drawn by the promise of a sugar "high" from the nectar inside, insects enter through the slit… On the way out the insect is plastered with a natural

glue on which, in turn, pollen is dusted. Emerging from the flower with cargo (of pollen) and payment (in nectar) the insect goes to another flower where, in the same intricate exit process, some of the pollen is deposited on the stigma to fertilize the plant and produce new seed." Of course, *Cyp. acaule* has no nectary, therefore there is no payment in nectar; pollen is not dusted; and the picture of an insect "plastered with natural glue" is entirely missleading. Because the above passage occurs in chapter one, a suspicion tends to be planted early as to the accuracy of the rest of the text.

The authors are to be commended in producing a book dedicated to the ever growing threats to our natural environment. Although the scope of this volume is limited to the Cape Cod area of Massachusetts, its message could equally apply to almost anywhere in North America.

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Lewis Clark's Field Guide to Wild Flowers of the Sea Coast in the Pacific Northwest

Compiled and photographed by Lewis J. Clarke, edited and composed by John G. Trelawny. 2004. Harbour Publishing P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 80 pages. Second Edition.Canadian $12.95.

The first edition of this beautiful little book was published by Gray's Publishing Limited, Sidney, British Columbia, in 1974 and numbered 64 pages. In this second edition which numbers 80 pages, John Trelawny has made some changes in the introduction and included some acknowledgements. Like the first edition, the pages are not numbered, but each species and the accompanying descriptive text is numbered sequentially so that they can readily be found from the index which includes both scientific and common names.

The 95 flower pictures in this second edition are absolutely beautiful and in many are somewhat clearer than those in the first edition because of more modern technology in producing them from the photo slides and like the 1974 edition each photo has a scale marker which gives the size of the picture in relation to the average plant size. A glossary at the end of the volume depicts various leaf shapes and flower parts to aid the user in understanding the descriptive text which accompanies each photograph. New plant photographs have been provided by T. & S. Armstrong, M. Barker, Ugo Cagnetta, W. Merilees, F. Pratt, H. Roemer, W. van Dieren, and M. Wheatley.

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Wild Flowers of Field & Slope in the Pacific Northwest

By Lewis J. Clark. 2002. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 108 pages.Canadian $9.95. Paper

Wild Flowers of Forest & Woodland in the Pacific Northwest

By Lewis J. Clark. 2003. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 100 pages. Canadian $12.95.

Wild Flowers of the Mountains in the Pacific Northwest

By Lewis J. Clark. 2003. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 106 pages. Canadian $12.95.

These three books contain absolutely beautiful colour photographs. The photographs are numbered sequentially and each one has a marker [×0.5] to indicate its size and is accompanied by a printed paragraph with the common and scientific names, a detailed description, together with the habitat and range, and a number to indicate its sequence in the book. There are 108 in the first book, 100 in the second and 106 in the third. There is a four or five page interesting introduction at the front of each book and an index, glossary and a list of Additional Field Guides available from Harbour Publishing at the end. There are most interesting pictures on the front covers of each book. On the back covers there is a note about the author, Dr. Lewis J. Clark together with a map of the Pacific Northwest on which there are shaded areas depicting where the wild flowers can be found. All are elegant.

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ENVIRONMENT

Conserving Living Natural Resources in the Context of a Changing World

By Bertie Josephson Weddell. 2002. Cambridge University Press, 40 West 20th Street, New York, New York 10011-4221 USA. 426 pages. £70 Cloth, £24.95 Paper.

Conserving Living Natural Resources in the context of a changing world is an excellent information source for anyone interested in natural resource management; in the evolution of attitudes, mainly North American, and knowledge regarding natural resources; in the development, over time, of the relationship between human beings and the natural environment – or any combination of the above.

Weddell writes in the preface that she designed the book as an introduction to natural resource conservation for students, and as a review for managers. As such it covers three different approaches to natural resource management – utilitarian, preservationist, and sustainable-ecosystem – in more or less chronological order.

For each approach, Weddell traces the historical conditions that set the stage for that type of resource management and discusses its strengths and weaknesses. She also explains the approach's central concepts, both philosophical and scientific, and describes its principal techniques. Weddell makes sure to emphasize why it is important to learn about the different approaches, even if certain aspects are now slightly outmoded. She makes four excellent points: (1) that there is no single correct way to manage natural resources; (2) that our generation has not necessarily discovered "the truth"; (3) that it is important to understand how we got to where we are today so that we can learn from our mistakes; and (4) that some of the approaches discussed in the book, even if they are out of date, are still widely applied today.

Part I of the book, "Management to maximize production of featured species – a utilitarian approach to conservation", discusses the commodification of resources, the impacts (habitat alteration, species declines, extinctions) of the commodification, and the responses (regulation, protection) to those impacts. It also traces the development of the discipline of natural resource management, describes the central concepts of the utilitarian approach (population growth, interactions between populations, habitats), and explains its main techniques (harvest management, habitat management, management to minimize conflicts between pest species and people).

In Part II, "Protection and restoration of populations and habitats – a preservationist approach to conservation", Weddell describes economic and demographic changes after World War II, and discusses the increasing awareness of ecological problems during that period (invasive species, toxic substances, ongoing extinctions). She also covers the rise of preservationist management, its central concepts (causes of extinction, speciation, classification), and the principal techniques relating to species protection and restoration, and to ecosystem protection and restoration.

In Part III, "Management to maintain processes and structures – a sustainable-ecosystem approach to conservation", Weddell provides an overview of more recent pressures to move beyond the protection of species and reserves, including practical, scientific, political, ethical and philosophical considerations. She also traces the rise of sustainable-ecosystem management, describes its central concepts (equilibrium theories, the flux of nature), and discusses two main techniques: conserving natural processes and contexts, and including people in the conservation process.

The book covers a lot of ground, much of it fairly complex, and it isn't short. But Weddell's clear and simple writing style makes the content is easy to read and understand. And she includes lots of helpful diagrams and dynamic examples. It all makes for pleasant and highly informative reading – particularly the historical background sections, which provide a valuable and relevant context for understanding the discipline of natural resource management.

Weddell closes the book by emphasizing that each of the natural resource management approaches – utilitarian, preservationist and sustainable-ecosystem – has much to teach us about solving contemporary problems. She stresses that each approach has advantages and disadvantages that make it appropriate to particular circumstances, and that it is possible to blend elements from all three approaches.

She also points out, and I quote: "I believe that as we continue to search for responsible ways to manage living natural resources, a large dose of humility is appropriate. Science, whether theoretic or applied, is an ongoing process.... Although our understanding of the natural world is more detailed than it used to be, there is still a lot we do not know. Management should err on the side of caution, therefore. There will always be surprises." Wise words.

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Visions of the Land: Science, Literature, and the American Environment from the Era of Exploration to the Age of Ecology

By Michael A. Bryson. 2002. The University of Virginia Press, Box 400318, Charlottesville, Virginia 22904-4318 USA. 228 pages. U.S. $16.50. Paper.

Visions of the Land, part of an "Explorations in Ecocriticism" series, is an interesting look at the relationship between science, the natural environment and human beings, as expressed in literature published in the United States from, as the subtitle suggests, the period of exploration in the 19th century to roughly the 1960s. Some aspects of that relationship would also apply to Canada.

The authors examined in the book cover quite the range – from explorers John Charles Frémont (American West) and Richard Byrd (polar regions), to author and feminist Charlotte Perkins Gilman, naturalist Susan Fenimore Cooper, and scientists John Wesley Powell, Rachel Carson and Loren Eiseley. The types of writing also vary widely – from exploration narratives and technical reports, to fictional utopias, natural histories, popular scientific literature, and more.

The book is divided into three parts: 1. Narratives of Exploration and the Scientist-Hero (Frémond and Byrd); 2. Imagined Communities and the Scientific Management of Nature (Powell and Perkins Gilman); and 3. Nature's Identity and the Critique of Science (Fenimore Cooper, Carson and Eiseley). The book's sub-title suggests a certain chronological order in the material, but that turned out not to be the case, which made reading and comprehension a little confusing. It was also a little difficult to follow the author's arguments through the themes covered in the three parts. I would have found it more effective had Bryson simply written a chapter on each of the authors.

Nevertheless, there is lots of good content in the book regarding science and connections with human perspectives on the natural environment. Frémont, for example, was the "glamour boy of American westward expansion", the archetypal macho scientist-explorer, who worked and wrote both scientific reports and popular literature at a time when the country was expanding ever faster westward, and when surveying technology and cartographic techniques were continually improving. Frémont's writing combines descriptive and poetic elements with analytical, quantitative elements. The science he practises and expresses is highly rational and empirical, and the land something to be studied, catalogued and mapped.

John Wesley Powell, featured in Part 2 of the book, is another fascinating character in the history of the American West. An explorer-scientist like Frémont – as well as an ethnologist, philosopher, writer and government leader – Powell was, according to Bryson, "one of the most important and influential scientists of his age." Powell's work emphasises the scientific control of a mechanistic nature while at the same time recognising nature's self-regulating properties and the need for careful settlement and agricultural practices. Powell is aware of and interested in community, particularly with respect to the need for human communities to develop a responsible relationship with nature and to use science wisely.

Susan Fenimore Cooper, featured in Part 3, is one of the two non-scientist writers discussed by Bryson, although she was a dedicated naturalist and keen observer. Her work falls into the 19th century natural history writing tradition which helped inform the ecological science developed in the following century. Her book, *Rural Hours*, published in 1854, combines natural history, cultural analysis and personal stories to create an environmental and social portrait of her home region in central New York state. Bryson finds *Rural Hours* fascinating "not only because it combines multiple strands of the nature writing tradition but also because it provides a complex and fairly substantial critique of the relation between nature and the human community." Fenimore Cooper views science not as something which can be used to objectify or control nature, unlike Frémont or Powell. Science, in her view, is a "system of study meant to foster moral and intellectual connections between the observer and the outside world."

I learned a lot about the evolution of scientific thinking and its influence on the human-nature relationship in *Visions of the Land*. I also discovered some fascinating writers and books – ones I'm sure to look up and enjoy in the future.

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Genetics, Demography and Viability of Fragmented Populations

Edited by A. G. Young, and G. M. Clarke. 2000. Cambridge University Press, 40 West 20th Street New York, New York 10011-4221 USA. 438 pages. Canadian $63. Paper.

This is another Australian CSIRO (Commonwealth Scientific and Industrial Research Organization) flagship publication of international importance to research and conservation. "The continuing global trend towards non-sustainable exploitation of natural resources means that more, rather than fewer, species are going to be affected by habitat loss, degradation and fragmentation in the future". The editors of this important book make it clear that the species of this globe will either have to survive in zoos, or in smaller fragments. For instance, the range of many Australian mammals declined already by over 90% and is now confined to off-shore islands; and in New Zealand the native forest cover has already been reduced from 78% in pre-human times to 23% today. Obviously, for many plants and animals in the world, preservation with relatively intact habitats is no longer an option.

Already Darwin (1876) had documentated inbreeding depression in both cultivated and native plant species. The two major goals of modern conservation genetics are the maintenance of genetic variation and the avoidance of inbreeding depression.

This book consists of three parts (Introductory Concepts, Animal and Plant Case Studies) and includes 20 research papers from 42 international authors. Most of the contributors come from the southern hemisphere (Australia and New Zealand) as well as from the English speaking research sphere (USA, UK). However, their research applications come from many parts of the world and cover the variety of the animal kingdom (Red-cockaded Woodpecker, Golden Lion Tamarins, Mexican Wolves, Bonytail Chub, Chinook Salmon, Golden Sun Moth, Desert Bighorn Sheep, small mammals) and a variety of plant species. The plant section is of special interest here as plants are used to present genetic mechanisms transferable to animal populations and their conservation. It even includes an endangered dry forest tree species (*Swietenia humilis*) in Central America now listed with CITES (as are two Mahagoni tree species; formerly of major economical value). I also admire the 54 pages of references and a detailed book index.

Although local extinction is not infrequent to observe in nature "Habitat destruction is the most obvious cause of species decline and the most difficult to reverse". Recent fragmentation shaped the global landscape nowadays, which has nothing to do anymore with the original habitat. This books makes a pledge that we need to find a limit how we affect the global environment. "The techniques for doing so will come more from economics, psychology and sociology rather than from biology". However, as the editors show, biology has an important role to play beyond identification of species and ecosystems.

It's a challenge to find the right gene that determines inbreeding in a cost-effective way. The book is full of GGTGCTAGs, Dendrograms, Nei Genetic Distances, Phylogenies etc. The presented papers report in great detail on DNA extraction and processing methods such as PCR, but less so on statistics. Commonly applied software packages and methods to derive evidences are GENEPOP, GenAlEx, SPARKS, PROC INBREED (SAS), PCA, bootstrapping, VORTEX and RAMAS. Authors conclude that relying entirely on neural molecular markers is inadequate. Most of the presented gene studies in this book are based on mtDNa and Allozymes; microsatellites might track fragmentation processes quicker.

Concepts and terms like Minimum Viable Populations (MVP) metapoluation paradigm, effective population size, rescue effect, simulation models, demography, transition matrix and the movements of pests, pathogens and predators are discussed as well. Some of the presented studies cover a period of over 10 years.

The well known study on Cheetah inbreeding effects (e.g., population decline, susceptibility to disease) remains controversial. But in Bighorn Sheep, high heterozygosity is known to be associated with large horn size at sexual maturity, which confers breeding superiority. It is worthwhile to note that over the last 200 years alone 98% of Desert Bighorn Sheep populations have been reduced.

This complex publication makes for a bible on fragmentation as being genetically harmful.

Much of the book deals with the landmark publications by Caughley (1994) and Lande (1988) and provides further evidence and research on these topics. It is in support of the classical conservation arguments; e.g., Those brought forward by Soulé. The book somewhat promotes the Australian conservation view, which might not necessarily be shared world-wide. For instance, the foreword cites Randal O'Toole (1999) who stated that "conservation biology is not a science but a political movement based at least in part of nineteenth-century ideals of what an ecosystem is all about". The reader of this book will definitely learn that genetic loss will have negative effects on economic and physical well-being. "Each extinction erodes the biological legacy, and humanity slips away. Stewardship for the planet and its inhabitants will have been lost, replaced by greed, ignorance, and shortsightedness". Brooks (1997) contemplated already that "while the ship is sinking, conservation geneticists are busy counting the deck chairs". The contributing authors to this book make a case for managing through genetics; they are frank about the fact that many problems with endangered species cannot be solved with genetic techniques alone but that genetics will allow for much more informed decisions. As the authors show, true population estimates are hard to get from field work, and DNA offers major opportunities to infer some basic life-history, demographic and population parameters.

I am very glad that this book stresses the importance of spatial issues for PVA, but true GIS papers are unfortunately not presented. Some papers deal indirectly with what can be defined as Landscape Ecology though. Readers will also appreciate the great summary of the most important elements of a successful PVA. Some really good model philosophy is presented, too. PVAs are coined as a "loaded gun" pointing towards economics and others. The book deals nicely with data uncertainties in PVAs, PVA acceptance in the research community and PVA applications, too. "Incomplete information does not mean that meaningful results are impossible to obtain because there is very significant value in building a model for its own sake", e.g., as a guide for further data collection and bringing stakeholders together. A key argument is that a PVA compares risk, but does not measure it.

Besides the many other interesting and important papers in this book I, personally, really like the one dealing with the faunal collapse and genetic erosion in small mammal communities on islands in the Chiew Larn reservoir in Thailand: it's an island habitat mile stone study with a 10 year data set.

The presented plant studies are very valuable because plants as well as their response to habitat loss and fragmentation, are usually understudied. The pollination papers show nicely that fragmentation has to consider pollinators (bees and butterflies), too, besides the pollen-mediated gene flow.

The correlation between population size and genetic diversity is clear. This book supports the view that it is increasingly apparent that the consequences of fragmentation are dependent upon complex interactions of demographic and genetic variables. However, the relative importance of demography vs. genetics for conservation of small populations or rare species is still debated. In either case, inbreeding and reproduction failure alone have limited demographic effects. However, when both are combined, and certainly when applying the "precautionary principle" in conservation, the two result in significantly reduced population persistent times. The authors show well that multidisciplinary approaches are crucial but that there is a large degree of discipline rivalry perpetuated by the structure of university faculties and departments and by the patterns of research funding worldwide. DNA studies must remain incomplete as long as prey, predation, landscape and other factors get ignored.

Unfortunately, data reported upon in this book are not freely available in a digital format for the public, nor is that fact anywhere in this book emphasized; the important topic of Metadata is not mentioned either. This does not add to transparent decision making in conservation and should be considered in any study.

As this book once more shows very clearly, "currently, we do have tools available to us that we are not using". If there is something to criticize in this book then: Why do we produce, and focus on, superb science, whereas most of our governments and the public are over 15 years behind in their actions and implications towards efficient conservation? In the meantime, the global landscape will be further exploited, with book shelves getting bigger. This excellent book calls for action: Management considering genetics is required.

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A Primer of Ecological Genetics

By Jeffrey K. Conner and Daniel L. Hartl. Sinauer Associates, Inc., Publishers, 23 Plumtree Road P.O. Box 407, Sunderland, Massachusetts 01375-0407 USA. 304 pages. U.S. $47.92.

Recent developments in molecular biology have lead to the application of increasingly sophisticated genetic techniques to ecological questions. *A primer of ecological genetics* serves as an introduction to this rapidly expanding field. The intended readers for this book are advanced undergraduate and graduate students who will find it a valuable resource in their studies. The authors also suggest that professional biologists will benefit from the material presented, but I don't think this audience is as well served.

The book starts with the basic concepts of population genetics, including a review of the most commonly used molecular markers. Conner and Hartl then guide the reader through theoretical and empirical advances gained from two complementary approaches to this field. The first is the study of genetic variation in natural populations. Observed levels of genetic variation are routinely used to assess breeding systems, migration, and differentiation within and among populations, making a sound understanding of this material essential for anyone working in conservation biology. The second approach, quantitative genetics, deals with insights gained from experimental studies. While much of the relevant literature addresses breeding programs, the authors argue convincingly for the value of quantitative genetics in studying natural populations.

A detailed discussion of natural selection follows, and the closing chapter of the book covers some of the major applications of population genetics – conservation genetics, evolution of invasive species, transgene escape, and the evolution of pesticide resistance. This last chapter is an excellent grounding for the book, providing concrete examples of the value of ecological genetics to real world problems.

Overall the book is well thought out, and the authors succeed for the most part in presenting this complex subject in an accessible way. The prominence of quantitative genetics in the text is refreshing. The demands required for quantitative genetic study have limited its use in a conservation context. Conner and Hartl may persuade some researchers to rise to the challenge and combine observational and experimental work. The determined individuals that do will likely produce some very interesting results!

Some of the discussion was over-simplified. The reader gains a general understanding of the concepts, but will need to refer to the primary literature or a more detailed reference to truly master the material. This is the authors intention, as evidenced by the excellent selection of current references included with each chapter, accompanied by discussion questions. In this light, the book will make a marvellous study guide for a graduate seminar or senior undergraduate course. However, professional biologists and conservation managers are less likely to have the time and energy to devote to the subject. Expanding the treatment to make this book a "one-stop" reference would better serve this audience.

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MISCELLANEOUS

Smithsonian Institution Secretary Charles Doolittle Walcott

By Ellis L. Yochelson. 2001. Kent State University Press, 307 Lowry Hall, P.O. Box 5190, Kent, Ohio 44242 USA. 590 pages. U.S. $49.00.

This, the second and final volume of Yochelson's massive "insider" biography (Yochelson retired from the Smithsonian in 1985), is clearly a labour of love. The first volume, Charles Doolittle Walcott, Paleontologist, appeared in 1998. From Walcott's daily diaries, an unusual amount of detail is provided chronologically, month by month, as a record for future historians. Fifty pages describe happenings in 1927 alone, when Walcott was already seventy years old.

Charles Doolitte Walcott was a man of humble and inauspicious beginnings, without any opportunity for a college education. In his early twenties he sold a collection of fossils to Louis Agassiz at Harvard University; a few years later he was offered a job as a temporary field assistant, measuring the thickness of rocks in Bryce Canyon, Utah, for the newly formed United States Geological Survey. A man of great tact and wisdom, Walcott never looked back; in 1933 the fifth edition of American Men of Science listed him posthumously as the third most important geological scientist in the country, and he collected twelve honorary degrees from as many universities.

Walcott is of enormous importance to Canada. He spent about three months each summer for 18 of 19 years, 1907 through 1925, studying geology and paleontology in the Canadian Rocky Mountains. In Yoho National Park, above Emerald Lake, he discovered the Burgess Shale, rated world-wide by Stephen Jay Gould as "the most precious and important of all fossil localities." In addition to his heavy administrative duties during the remainder of the year, Walcott spent his spare hours in winter studying and describing these fossils. This lifelong devotion to his field of science is all the more remarkable when one considers his burdensome official duties. From 1907 until his death in 1927 he occupied the powerful post of secretary of the Smithsonian Institution. He also served variously as president of the Paleontological Society, National Parks Association, American Philosophical Society, Washington Academy of Sciences, National Academy of Sciences, and the American Association for the Advancement of Science, was chair of both the Carnegie Institute of Washington and the National Advisory Committee for Aeronautics, and was First Vice Chairman of the National Research Council and the American Federation of Arts. One of the most powerful men in Washington, a mover and a shaker, Walcott dined with presidents, cabinet members, supreme court justices, and foreign diplomats. In spite of these pressures, Walcott was a devoted husband and father. His chauffeur, butler, furnace stoker, and loyal family retainer at home in Washington, Arthur Brown, was also his camp manager, nurse, cook, general guardian and friend in each of his mountain camps, and the "unofficial mayor of black Washington."

Walcott's first wife, Lura, died of tuberculosis less than two years after their marriage. Thirteen years later, in 1888, he married Helena Stevens; their honeymoon was spent looking at rocks in Newfoundland. Helena was a competent geologist who, at her first International Congress of Geology in London, England, corrected the reversal of Middle and Lower Cambrian levels previously described for New York State rocks. According to daughter Helen's reminiscences, her mother Helena was also the first to split open a piece of Burgess shale, lying by the trail, while waiting for her husband to climb the scree above. It proved to have an unusual diversity and complexity of fossils, included many soft-bellied organisms, unequalled anywhere in the world. Helena had four children, all but the oldest of whom accompanied them on one or more summer geology expeditions to Canada. Helena died in a train accident in Connecticut in July 1911, so Walcott had a much shortened field season that year.

In 1914, Walcott married Mary Vaux, shortly before her fifty-fifth birthday. A Philadelphia Quaker, she had measured and photographed, with her father, George Vaux, the movements of Illecillewaet and other glaciers in the Canadian Rockies, since the 1880s. Mary took the place of Helena in assisting with fossil collecting, but also painted superb portraits of wildflowers. Towards the end of his life, Walcott assisted Mary Vaux Walcott in having the Smithsonian Institution publish her sumptuous five-volume North American Wild Flowers, "the monumental … Audubon of the floral world." The alpine flowers were painted while with her husband in the Canadian Rockies.

Yochelson inserts chatty comments about many topics, including Walcott's children. Citations are satisfactory, but index entries are haphazardly incomplete. I detected nine spelling or typographical errors.

In the final chapter, Yochelson succinctly and convincingly counters some of the grossly unfair impressions left after reading Stephen Jay Gould's best-selling *Wonderful Life: The Burgess Shale and the Nature of History.* Contrary to Gould's intimations, Walcott supported the concept of evolution, "an act of considerable courage, not an indication that he was hidebound in his thinking … Walcott did not propose new classes and new phyla. The time was simply not ripe … Gould has judged Walcott by the context of his own notions more than half a century later." Walcott's

detailed descriptions of the fossil organisms in the Burgess shale clearly ranks as among the greatest discoveries in paleontology.

Any reader of this review who has read Gould's *Wonderful Life*, should read Yochelson's final chapter, and each library that holds a copy of Gould,should add this book as well as Simon Conway Norris' *The Crucible of Creation* as a rebuttal. On its own merits, Yochelson's book deserves to be in every major library.

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NEW TITLES

†Available * Assigned

Zoology

Amphibians and Reptiles of Pakistan. By M. Khan. 2005. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902 USA. No price available.

The Amphibians and Reptiles of El Salvador. By G. Kohler, M. Vessely and E. Greebaum. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902 USA. No price available.

The Anatomy of Reptiles. By J. Wyneken. 2005. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902 USA. No price available.

***Birds of Australia – Seventh Edition.** By K. Simpson and N. Day. 2004. Princeton University Press, 41 William Street, Princeton, New Jersey, 08540-5237 USA. 392 pages. U.S. $39.50.

Birds of the Raincoast. H. Thommasen and K. Hutchings. 2004. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 200 pages. Can $44.95. Cloth.

***A Citizen's Guide to Ecology.** By L. Slobodkin. 2004. Oxford University Press Canada, 70 Wynford Drive, Don Mills, Ontario, M3C 1J9. 245 pages. U.S. $14.95. Paper.

Dictionary of Herpetology. By H. Lillywhite. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902 USA. No price available.

The Exotic Amphibians and Reptiles of Florida. By W. Meshaka, B. Butterfield and B. Hague. 2004. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902 USA.166 pages. U.S. $34.50.

Experimental Approaches to Conservation Biology. Edited by M. S. Gordon and S. M. Bartol. 2004. University of California Press, 2120 Berkeley Way, Berkeley, California 94704-1012 USA. 358 pages. U.S. $75.00.

A Field Guide to the Reptiles and Amphibians of Bali. By J. L. McKay. 2005. Krieger Publishing P.O. Box 9542, Melbourne, Florida 32902 USA. No price available.**Guide to the Amphibians and Reptiles of Japan.** By R. Goris and N. Maeda. 2004. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902 USA. 296 pages. U.S. $69.50. Cloth.

***Mammals of the World – A Checklist**. By A. Duff and A. Lawson. 2004. Yale University Press, P.O. Box 209040 New Haven, Connecticutt 06520-9040 USA. 312 pages. U.S. $45.00.

†**The Monarch Butterfly – Biology and Conservation.** By K. Oberhauser and M. Solensky (*Editors*). 2004. Cornell University Press, 512 East State Street, Ithaca, New York 14850 USA. vii + 248 pages. U.S. $39.95.

Our Life with Birds. By J. and G. Tveten. 2004. Texas A&M University Press, Lewis Street, 4354 TAMU, College Station, Texas 77843 USA. 256 pages. U.S. $24.95. Cloth.

The Panther Chameleon. By G. Ferguson, J. Murphy, J. Ramanamanjato and A. Rasselimanana. 2004. Krieger Publishing P.O. Box 9542, Melbourne, Florida 32902 USA. 166 pages. U.S. $39.50 Cloth.

Penguins of the World. By W. Lynch. 2004. Firefly Books Ltd., 3680 Victoria Park Avenue, Toronto, Ontario M2H 3K1 Canada. 144 pages. Can $35.00. Cloth.

† **Prairie Ghost – Pronghorn and Human Interaction in Early America.** By R. McCabe, B. Ogera, H. Reeves. 2004. University Press of Colorado, 5589 Arapahoe Avenue, Suite 206C, Boulder, Colorado 80303 USA. 208 pages. U.S. $29.95. Cloth.

Snakes of the Americas: Checklist and Lexicon. By R. Tipton. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902 USA. No price available.

Status and Conservation of Florida Amphibians and Reptiles. By W. Meshaka, and K. Babbitt. 2005. Krieger Publishing P.O. Box 9542, Melbourne, Florida 32902 USA. No price available.

***The Wolves of Algonquin Park a 12 Year Ecological study.** By J. and M. Theberge. 2004. University of Waterloo, Waterloo, Ontario. Contact bkevans@fes.uwaterloo.ca. Canadian $ 23.50 Paper.

Botany

Biological Control of Invasive Plants in the United States. Edited by E. Coombs, J. Clark, G. Piper and A. Cofrancesco. 2004. Oregon State University Press, 102 Adams Hall, Corvallis Oregon 97331 USA. 448 pages. U.S. $45.00. Paper.

† **Emulating Natural Forest Landscape Disturbances – Concepts and Applications.** By A. Perera, L. Buse, and M. Weber. 2004. Columbia University Press, 61 W. 62nd Street, New York, New York 10023 USA. 352 pages. U.S. $74.50. Cloth.

***Gathering Moss – A Natural and Cultural History of Mosses.** By R. Kimmerer. 2004. Oregon State University Press, 102 Adams Hall, Corvallis, Oregon 97331 USA. 176 pages. U.S. $17.95. Paper.

Klamath Heartlands – A guide to the Klamath Reservation Forest Plan. By E. Wolf. 2004. Oregan State University Press, 102 Adams Hall, Corvallis Oregon 97331 USA. 56 pages. U.S. $19.95. Paper.

Tree – A life Story. By D. Suzuki and W. Grady. 2004. Greystone, #201 – 2323 Quebec Street Vancouver, British Columbia V5T 4S7 Canada. 192 pages. Canadian $28.00 Cloth.

Environment

Death Takes a Gander. By Christine Goff. 2004. CLG, Box 3280, Evergreen, Colorado 80437 USA. 224 pages. U.S. $5.99. Paper.

Managing Environmental Policy: A Casebook. By R. Watson, D. Kiel, and S. Robar. Krieger Publishing. P.O. Box 9542, Melbourne, Florida 32902 USA. 180 pages. U.S. $27.50. Cloth.

Prairie – A Natural History. By Candace Savage. 2004. Greystone, #201 – 2323 Quebec Street Vancouver, British Columbia V5T 4S7 Canada. 320 pages. Canadian $60. Cloth.

The Sacred Balance. By D. Suzuki and A. McConnnell. 2004. Greystone #201 – 2323 Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 160 pages. Canadian $34.95. Cloth.

Young Naturalists

Hummingbirds. By L. Aziz. 2004. Firefly Books Ltd., 3680 Victoria Park Avenue, Toronto, Ontario M2H 3K1 Canada. 64 pages. Canadian $9.95. Paper.

Penguins. By W. Lynch. 2004. Firefly Books Ltd., 3680 Victoria Park Avenue, Toronto, Ontario M2H 3K1 Canada. 64 pages. Canadian $ 9.95 Paper.

News and Comment

Froglog: Newsletter of the Declining Amphibian Populations Task Force (63, 64)

Number 63, June 2004. Contents: Status of Three Species if Toads in North–western Mexico (Georgina Santos Barrera & Jesus Pacheco Rodriguez) — Ranids to the Rescue! (Jerry Lea & Luca Luiselli) — Effects of Habitat Loss and Fragmentation on Anurans in Espinal Eco–region, Argentina: a GIS approach (Paola Peltzer, G. Bock, R. Tardivo & R. Lajmanovich) — DAPF Rapid Response Fund — Reports on DAPTF Seed Grants — Froglog Shorts.

Number 64, August 2004. Contents: Morphological Abnormalities in Frogs of West Java, Indonesia (Mirza D. Kusrini, Ross A. Alford, Anisa Fitri, Dede M. Nasir, Sumantri Rahardyansah — Press Release: Concerns Remain About UV–B Damage To Amphibians (Andy Blaustein) — New Laboratory of Natural Sounds in Cuba (Ansel Fong Grillo) — Reports on DAPTF Seed Grants (Tim Halliday) — WebFroglog [see www.opem.ac.uk/daptf and www.open.ac.uk/daptf/froglog] — Announcements and Meetings.

Froglog is the bi–monthly newsletter of the Declining Amphibian Populations Task Force of The World Conservation Union (IUCN)/Species Survival Commission (SSC) and is supported by The Open University, The World Congress of Herpetology, and Arizona State University. The newsletter is Edited by John W. Wilkinson, Department of Biological Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, United Kingdom; e–mail: daptf@open.ac.uk. Funding for *Froglog* is underwritten by the Detroit Zoological Institute, P. O. Box 39, Royal Oak, Michigan 48068–0039, USA. Publication is also supported by Peace Frogs www.peacefrogs.com and by RANA and the US National Science Foundation grants DEB–0130273 and INT–0322375.

Marine Turtle Newsletter (105)

July 2004. 32 pages: articles: The Status and Conservation of Sea Turtles in Kenya — Observations of Loggerhead Turtles Feeding on Discarded Fish Catch, Kefalonia — notes: Back to the Old Ways — letters to the editor: TEDs 00 — meeting reports — IUCNMTSG Update — book reviews — news & legal briefs — recent publications.

The Marine Turtle Newsletter is edited by Brendan J. Godley and Annette C. Broderick, Marine Turtle Research Group, Centre for Ecology and Conservation, University of Exeter in Cornwall, Tremough Campus, Penryn TR10 9EZ United Kingdom; e–mail MTN@seaturtle.org; Fax +44 1392 263700. Subscriptions and donations towards the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael Coyne (online Editor) Marine Turtle Newsletter, 1 Southampton Place, Durham, North Carolina 27705 USA (e–mail: mcoyne@seaturtle.org).

The Boreal Dip Net/L'Epuisette Boreal: Newsletter of the Canadian Amphibian and Reptile Conservation Network – Reseau Canadien de Conservation des Amphbiens et des Reptiles 8(2) June 2004

Contents: Editor's Note — Kawartha Turtle Trauma Centre: Now a Recognized Charity — 2993 Digital Frog – CARCNET/RECCAR Scholarship Winner Kimberley Pearson (Sara L. Ashpole) — A Survey if the Status of the Western Toad (*Bufo boreas*) in Mount Revelstoke and Glacier National Parks (Jesse Dykstra) — (Other) Upcoming Meetings: 18th Annual Meeting of the Society for Conservation Biology (Danna Schock) — The 9th Annual Meeting of the Canadian Amphibian and Reptile Conservation Network (CARCNET)/Reseau Canadien de Conservation des Amphibiens et des Reptiles RECCAR) Coast Terrace Inn, Edmonton, Alberta 24–27, 2004 — Seasonal and Diurnal Patterns of Calling in Eastern Canadian Amphibians: Compiling the conventional wisdom as a null hypothesis (Frederick W. Schueler with contributions from Wayne F. Weller, John Gilhen, Lenny Shirose, and Brian Dalzell — Membership in CARCNET/RECCAR (contact Bruce Pauli, Canadian Wildlife Service, National Wildlife Research Centre, Carleton University, Raven Road, Ottawa, Ontario K1A 0H3. Web site: http://www.carcnet.ca/).

Canadian Species at Risk May 2004

Issued by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the list is 49 pages containing: About COSEWIC: mandate, membership, definitions — Summary tables: Species designated in the "risk" and the Extinct categories and the Not at Risk, and Data Deficient categories (Tables 1–3) — Results of May 2004 COSEWIC meeting (Tables 4–5) — Explanation of status change symbols for reassessed species — COSEWIC Assessment Results — Table 6: Species assessed and designated Extinct: Extinct Category — Table 7: Species examined and designated in a "risk category": Etripated Category, Endangered Category, Threatened Category, Special Concern Category — Table 8, Species assessed and found to be on the Not at Risk category — Table 9. Species considered and placed in the Data Deficient category – Record of Status Re–examinations — Record of Name Changes. Listed as of May 2004 (with November 2003 totals in parenthesis) are 12 (12) extinct, 21 (21) extirpated, 169 (153) endangered, 114 (102) threatened, and 140 (143) of special concern. Of the 453 (431) forms in these categories, 66 (64) are mammals, 60 (56) birds, 32 (31) reptiles, 19 (19) amphibians, 79 (807) fishes, 16 (13) arthropods, 21 (18) molluscs, 145 (136) vascular plants, 11 (8) mosses, and 7 (6) lichens. In addition 151 (152) forms have been considered and found not at risk, and 33 (29) to be data deficient.

This publication is available from COSEWIC Secretariat, Canadian Wildlife Service, Environment Canada, Ottawa, Ontario K1A 0H3. See Web site: http://www.cosewic.gc.ca.

Erratum *Canadian Field-Naturalist* 118(2):

Back cover contents omission:

Replacement Figure 2, page 161 for
Morphology and population characteristics of Vancouver Island Cougars, *Puma concolor vancouverensis*,
STEVEN F. WILSON, APRYL HAHN, AARON GLADDERS, KAREN M. L. GOH, AND DAVID M. SHACKLETON

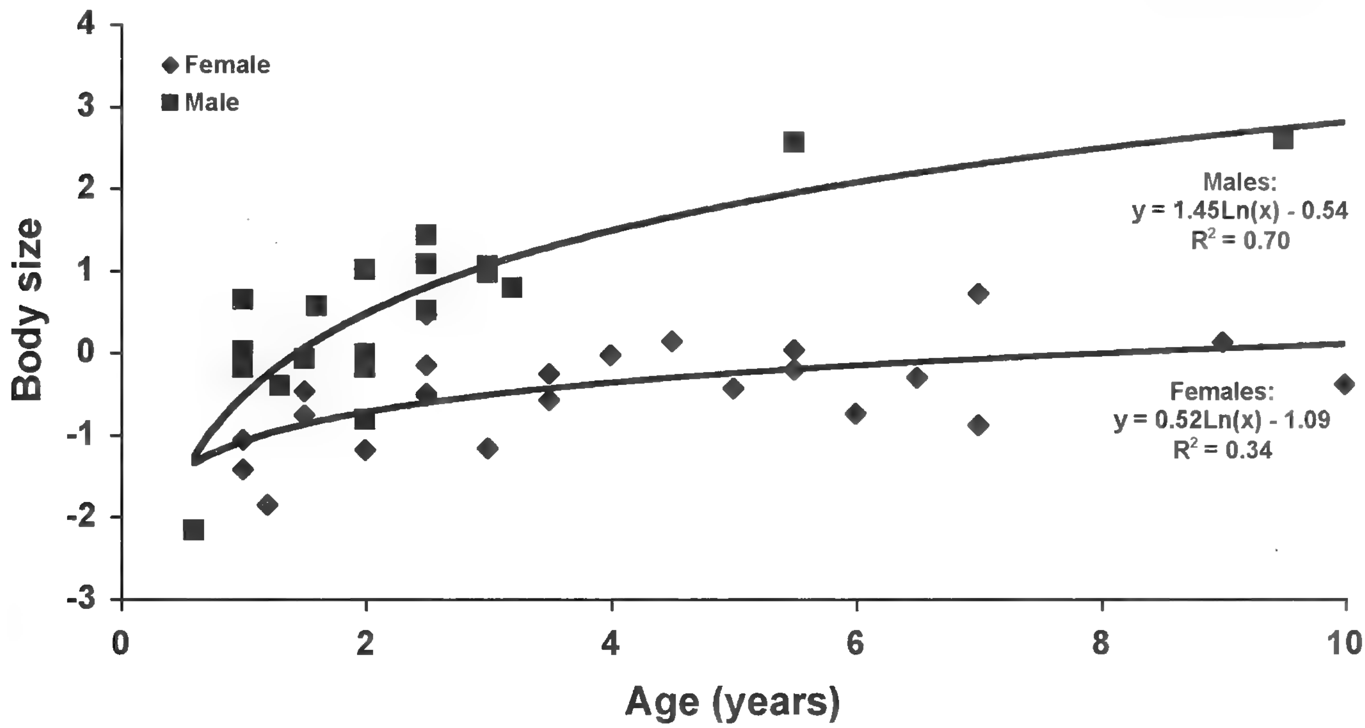

FIGURE 2. Relationship between body size (derived from the principal component analysis on morphological measurements, see text) and age for male and female Cougars in two Vancouver Island study areas. Logarithmic trend lines are presented for males (squares ■) and females (diamonds ◆) pooled by study area. The body size measurement was used because it was less condition-dependent than using total weight alone.

Minutes of the 125th Annual Business Meeting of The Ottawa Field-Naturalists' Club 13 January 2004

Place and time: Canadian Museum of Nature, Ottawa, Ontario, 7:30 p.m.
Chairperson: Garry McNulty, President
Attendance: Thirty-five persons attended the meeting.
Attendees spent the first half-hour reviewing the minutes of the previous meeting, the Treasurer's Report and the Report of Council. The meeting was called to order at 7:35 p.m. with some opening remarks from Gary McNulty, the President.

1. Minutes of the Previous Meeting

There were no changes to the minutes of the 124th Annual Business Meeting.

It was moved by Fenja Brodo/David Hobden that the minutes be accepted.

(Motion Carried)

2. Business Arising from the Minutes

Garry McNulty inquired whether we were still receiving the annual reports for the Trinidad and Tobago Naturalists' Club. Frank Pope reported that we were receiving their annual reports along with their newsletters.

The Soiree was revamped last year. Changes were made to the venue and entertainment was included in the course of the evening. Fenja Brodo, the new chair of the Excursions and Lectures Committee, will be working with the Education and Publicity Committee to continue the process of making the Soiree an evening that members will not want to miss.

3. Communications Relating to the Annual Business Meeting

There were no communications relating to the Annual Business Meeting.

4. Treasurer's Report

Frank Pope reviewed the financial report for the year ending September 30, 2003, noting that the Club's net assets had decreased by approximately $60,000. This was due in large part to the contribution of $55,000 to the Alfred Bog Fund.

Moved by Frank Pope and seconded by Roy John that the Financial Report be accepted.

(Motion Carried)

5. Committee Reports

Gary McNulty introduced each of the Committee reports and a representative of the appropriate Committee and asked for questions and comments. He thanked the committee chairs and committee members for their work over the past year.

Moved by Mike Murphy/Eleanor Zurbrigg, that the reports be accepted.

(Motion Carried)

6. Nomination of the Auditor

Moved by Frank Pope, seconded by Bill Cody, that Janet Gehr continue as Auditor for another year.

(Motion Carried)

7. Report of the Nominating Committee

President	Mike Murphy
Vice President	Gillian Marston
Secretary	Susan Laurie Bourque
Treasurer	Frank Pope
Past President	Gary McNulty
Business Manager	Bill Cody
Editor CFN	Francis Cook
Editor T&L	Karen McLachlan Hamilton

Committee Chairs

Birds	Chris Traynor
Computers	
Conservation	Stan Rosenbaum
E&P	John Cameron
E&L	Fenja Brodo
Finance	Louise Schwartz
FWG	David Hobden
Macoun rep	Barbara Gaertner
Membership	Dave Smythe
Publications	Ron Bedford
FON Rep	Cendrine Huemer

Members at large

Kathy Conlan
Diane Lepage
Barbara Gaertner
Christine Lewis
Henry Steger

Chairs not on Council

Awards	Ernie Brodo
Macoun	Rob Lee
Nominations	Fenja Brodo

Retiring from the Council: Charles Clifford, Roy John, Marcel Gahbauer, Eleanor Zurbrigg

New on the Council: Christina Lewis, Henry Steger

Moved by Fenja Brodo, seconded by Frank Pope, that the slate of nominations for the 2004 Council be accepted.

(Motion Carried)

8. New Business

There was no new business.

9. Presentation by David Hobden, "FWG and its Rise to Fame"

David Hobden presented an enjoyable and informative digital photographic presentation created by Henry Steger and

David Hobden. The presentation touched on the development and flora and fauna of the Fletcher Wildlife Garden. The digital format successfully combined prints, slides and digital pictures. It was very well received.

10. Adjournment

Fenja Brodo made an announcement about the upcoming 4th Annual Great Backdoor Bird Count.

Moved by Fenja Brodo/David Hobden that the meeting be adjourned at 9:15 pm. (Motion Carried)

SUSAN LAURIE-BOURQUE, Recording Secretary

The Ottawa Field-Naturalists' Club Committee Reports for 2003

Awards Committee

The Awards Committee met in January to consider nominations made for the various OFNC Awards. As a result of our deliberations, the following four awards for the year 2002 were presented at the OFNC's Annual Soirée, which took place 26 April 2003 at St. Basil's Church in Ottawa.

MEMBER OF THE YEAR:

Bill Royds: For his many contributions to the Club's conservation efforts, especially during this last year as the link between the OFNC and the Greenspace Alliance of Canada's Capital (GACC).

GEORGE MCGEE SERVICE AWARD:

David Hobden: For his active participation in the Conservation Committee and his enthusiastic, productive work on the Fletcher Wildlife Garden Committee.

CONSERVATION AWARD – MEMBER:

Philip Fry: For establishing and maintaining the "Old Field Garden" near Oxford Mills as a model for habitat restoration and wildflower gardening.

CONSERVATION AWARD – NON-MEMBER:

Michèle André-St. Cyr: For her relentless work in preventing the death of turtles along the highways of southern Ontario by the establishment of "Turtle Crossing" signs, and for her active and successful efforts in educating the public about turtles.

I. BRODO

Birds Committee

The Birds Committee participated jointly with the Club des Ornithologues de l'Outaouais to run a successful Christmas Bird Count in December 2002. The fall bird count was held again in October 2003 and continues to grow in popularity. We were again active in the Peregrine Falcon Watch at the downtown nest site. One female was successfully fledged. The Bird Record Sub-committee continues to review records of rare birds and is currently compiling a lengthy database of Ottawa bird records. The Bird Record Sub-committee also finished publication of the new Ottawa District Bird Checklist 2002. The checklist is available in many Ottawa nature stores. The third year of surveying for the Ontario Breeding Bird Atlas (Region 24) has been completed. There are plans to add five more under-surveyed squares from an adjacent region for the 2004 season. This years seed-a-thon raised close to $400.00 for the club's bird feeders. We continue to operate the rare bird alert and the Ottawa bird status line, a recorded telephone message of current bird sightings. Some members of the Committee participated in the Taverner Cup competition

C. TRAYNOR

Computer Management Committee

This year, the Committee reviewed and revised their Terms of Reference and the revisions were approved by the Council.

It also reviewed the state of the Club's Membership Database System application. Upon a recommendation by the Computer Management Committee, the Council approved the acquisition of Microsoft Access as the Club's data entry and database management technology. This product provides a relational database engine with VisualBasic language support for applications development. The Membership Database application will be redeveloped using Microsoft Access during 2004.

M. MURPHY

Conservation Committee

Since November 2002 the CC has been assisting local residents calling themselves Larose Defense Fund/Fond de défense Larose with opposition to a proposed zoning change within part of the forest. We expressed support for the preservation of francophone heritage at other locations. The Club contributed $1000 towards the Fund's legal costs at an OMB hearing.

In cooperation with the Greenspace Alliance of Canada's Capital, the CC appeared at City Planning and Development Committee in regard to the 3rd draft of the Official Plan. Some improvements were secured.

We helped the FON to hold this workshop at the Museum of Nature in Ottawa.

Several Club members reviewed the City's list of areas to be studied and suggested additional areas. Adrianne Sinclair of the CC was appointed to the Public Advisory Committee.

What in the 1970s the OFNC called the South Gloucester Conservation Area gradually became a quarry, but the 177 City-owned acres were known to support uncommon plant species. Despite intervention by the CC and the Greenspace Alliance, the City voted to sell this land to the quarry owner for $1.7M, but imposed requirements for environmental assessment, and assigned the sale revenue to a natural land acquisition fund.

S. ROSENBAUM

Education And Publicity Committee

The committee organized and managed OFNC participation in three major public events: the Ottawa Teachers Federation professional development day, the Carlingwood Wildlife Festival and Health Canada's celebration of Environment Week. The Wildlife Festival was the largest and most successful in attracting public interest. Twenty OFNC volunteers and five Macoun members assisted with this event.

A demonstration of bird songs using tapes and slides was provided as a pre-concert activity for the Young Peoples Concert Series at the NAC, April 26.

The Ottawa Field-Naturalists' Club presented three Natural History Awards of $50.00 each plus an OFNC membership at the Ottawa Regional Science Fair. The judges were Kathy Conlan and Susan Laurie-Bourque.

A French version of the club brochure was prepared and production begun at year's end.

The sales table at the club's evening presentations at the Canadian Museum of Nature provided revenue of $400.

J. CAMERON

Excursions And Lectures Committee

In 2003 this Committee arranged 38 events and nine monthly meetings including the ABM and the Soirée. Seven general interest excursions were offered to Club members. The Birds Committee ran 12 birding excursions, three bird counts as well as assisted with The Taverner Cup. Two of our monthly meetings were also devoted to birds. There were six botanical excursions or workshops and two mushroom activities. Insects were the subject of one excursion and two of our monthly meetings. Other excursions were for mudpuppies, astronomy and a museum visit. Workshops were also given on geology and on digital cameras. Two of our monthly meetings were devoted to conservation matters and one introduced us to polar environments.

The monthly meetings drew about 50 people on average. Excursions and workshops are designed for a smaller number of participants. This year we asked leaders to have participants sign a waiver form. The form is primarily designed to inform participants about liability but it provides a record of attendance.

F. BRODO

Executive Committee

The Executive Committee met in October to review several items that required responses and/or action plans. As a result of that meeting, action plans have been put in place to address the following issues in 2004:

(1) review of electronic publication possibilities
(2) digital photo archives
(3) how to retain new members
(4) system to record names and number of persons participating in club excursions and activities.

The Committee also reviewed the club's liability insurance, its role in the Taverner Cup, the issue of attracting volunteers and it put in place a succession planning exercise and a system to review and report on the publications of other nature clubs. These matters require further action in 2004 but should be completed by year end.

G. MCNULTY

Finance Committee

The Finance Committee met three times in calendar year 2003. The following items are highlighted: – a review of existing and proposed honoraria was undertaken. No changes to the current structure were recommended to Council.

- the committee recommended to Council that the Alfred Bog Fund be topped up by $4,000 from the de Kiriline Lawrence Fund, bringing the total OFNC contribution to $59,000.
- options for replacement accounting software were assessed but no decision was taken.
- a review of membership fees for 2004 was carried out, and the Committee recommended to Council that the fees not be raised for the upcoming year. However, given the expected year-end deficit, this issue will need serious consideration next year.
- a budget for fiscal year 2003-04 was tabled and approved at Council in the fall, showing a small projected deficit.
- other items such as the RoweCom bankruptcy, liability and directors' insurance, and Taverner Cup funding were discussed.

L. SCHWARTZ

Fletcher Wildlife Garden

Volunteers contributed over 3000 hours, mainly on Friday or Sunday mornings. Their work is particularly noticeable in the Backyard Garden. The Management Committee met eleven times during the year.

The big achievement for the year was the production of an agreement with Agricultureand Agri-Food Canada for use of the site and occupation of the building. Negotiations were completed in the summer and the agreement finally signed in November. It is to run until April 2006. We wish to thank Frank Pope for handling legal and insurance issues and the final signing.

During the year we held a public event for International Migratory Bird Day in May and our best plant sale ever in June thanks to Algonquin College and our own volunteers.

Our traveling display was seen at Seedy Saturday, The Wildlife Festival, Environment Day at Health Canada, an Invasive Species Workshop at the Museum of Nature and at the OFNC Soiree.

This year we had a part-time summer employee, since we did not obtain a grant to support the position as we had in previous years. She dealt with visitors, kept the Interpretation Centre open and worked mainly on invasive plant control, supplementing the work of a group of volunteers.

The Interpretation Centre was opened by volunteers on Sunday afternoons through the summer. Located there is a small library, including a complete collection of the Canadian Field-Naturalist, and two stereo microscopes for examining small specimens. The Centre was used for meetings by OFNC Council and four committees and for workshops.

D. HOBDEN

Macoun Field Club Committee

The committee met just once, to plan the start-up of the Macoun Club year; much of the work of organizing the program from month to month was done over the telephone and by e-mail. Some committee members arranged for speakers each week and supervised the meetings, while others led field trips twice a month. Some also led the high-school-age members on camping trips at Christmas and in June.

Through this program, the children and teenagers of the Macoun Club were introduced to local geology, lichens, plant biology, insects, and wildlife (both Canadian and exotic). Field trips gave members hands-on experience in identifying trees and animal tracks, and allowed them to take part in the Club's ongoing research on butternut canker disease, lichen biodiversity, and porcupine populations.

The monthly newsletter and the annually produced *Little Bear* magazine were both prepared by the young people themselves, while the Club's web site was maintained jointly with Committee members. Individual Macoun Club members presented natural science projects at the OFNC Soirée in April, and the Club's executive recounted the group's activities for the OFNC members assembled there.

R. LEE

Membership Committee

The distribution of memberships for 2003 is shown in the table (below), with the comparable numbers for 2002 in brackets. These statistics do not include the 23 affiliate organizations which receive free copies of the Club's publications.

This year, the Club lost a long time member and valuable contributor to the production of the Canadian Field-Naturalist (CFN), with the death of Dr. Wilson Eedy, member since 1970 and Book-Review Editor of the CFN for many years.

D. SMYTHE

Distribution of Memberships in The Ottawa Field-Naturalists' Club

	CANADIAN				FOREIGN					
Type	Local		Other		USA		Other		Total	
Family	317	(340)	23	(29)	1	(1)	1	(2)	342	(372)
Individual	323	(345)	111	(120)	24	(26)	6	(5)	464	(496)
Honorary	15	(15)	9	(9)	0	(0)	0	(0)	24	(24)
Life	21	(21)	20	(21)	7	(5)	1	(1)	49	(48)
Sustaining	11	(8)	3	(2)	0	(0)	0	(0)	11	(10)
Total	687	(729)	166	(181)	32	(32)	8	(8)	890	(950)

Publications Committee

The Publications Committee met twice in 2003.

Four issues of *The Canadian Field-Naturalist* were published in 2003: Volume **116,** #2,3,4 and Volume **117,** #1. These four issues contained 698 pages; 47 articles; 20 notes; 1 COSEWIC article; 81 book reviews; 144 new titles; 2 commemorative tributes; 24 pages of News and Comments; and a 29 page index.

The long-time Book Review Editor, Wilson Eedy, died suddenly in the summer. His position has been taken over by Roy John. All of the Associate Editors will be reappointed for 2004.

Six articles qualified for support from the Manning Memorial Fund for a total of $4044.

Steady progress was made in getting the publication schedule back on track. The printing of *The CFN* has been taken from St. Joseph and contracted to Gilmore Printing Services Inc. beginning with Volume **117,** #2. It is expected that this will both reduce the printing costs and improve the photographic quality.

In response to an author's complaint, the details of publication charges have been reworded. The new text says, in effect, that only members of *The Ottawa Field-Naturalists' Club* and subscribers to *The CFN* are eligible to apply for waiver of page charges for the first five pages, and then only if institutional funds are unavailable.

Volume 37 of *Trail & Landscape* was published in four issues containing 192 pages with the usual mix of good articles and news of *Club* events.

R. BEDFORD

Auditor's Report

To The Members of THE OTTAWA FIELD NATURALISTS' CLUB

I have audited the balance sheet of THE OTTAWA FIELD-NATURALISTS' Club as at September 30, 2003, the statement of changes in net assets, and the statements of operations. These financial statements are the responsibility of the organization's management. My responsibility is to express an opinion on these statements based on my audit.

Except as explained in the following paragraph, I conducted my audit in accordance with generally accepted auditing standards. Those standards require that I plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In common with many non-profit organizations, the Ottawa Field-Naturalists' Club derives some of its revenue from memberships, donations, and fund raising activities. These revenues are not readily susceptible to complete audit verification, and accordingly, my verification was limited to accounting for the amounts reflected in the records of the organization.

In my opinion, except for the effect of the adjustments, if any, which I might have determined to be necessary had I been able to satisfy myself concerning the completeness of the revenues referred to in the preceding paragraph, these financial statements present fairly, in all material respects, the financial position of the OFNC as at September 30, 2003, and the results of its operations and changes in net assets for the year then ended in accordance with generally accepted accounting principles.

JANET M. GEHR
Chartered Accountant

North Gower, Ontario
January 12, 2004

The Ottawa Field-Naturalists' Club
Balance Sheet
September 30, 2003

	2003	**2002**
ASSETS		
CURRENT		
Cash (Note 1)	$ 2,781	$ 71,087
Investment certificates (Note 1)	43,764	84,790
Marketable securities (Note 2)	246,467	235,758
Accounts receivable	27,690	7,238
Prepaid expenses	1,000	1,000
	321,702	399,873
CAPITAL ASSETS (Note 3)	–	–
Land – Alfred Bog	3,348	3,348
	$ 325,050	$ 403,221
LIABILITIES AND FUND BALANCES		
CURRENT		
Accounts payable and accrued liabilities	$ 2,000	$ 2,000
Deferred revenue	12,075	13,500
	14,075	15,500
Life memberships	12,663	11,721
NET ASSETS		
Unrestricted	60,609	80,325
Club reserve	100,000	100,000
Manning principal	100,000	100,000
Manning interest - OFNC	1,434	1,963
- CFN	13,153	13,179
Seedathon	1,618	2,087
Anne Hanes memorial	870	870
de Kiriline-Lawrence	18,798	23,975
Macoun Baillie Birdathon	1,337	1,327
Alfred Bog	493	52,274
	298,312	376,000
	$ 325,050	$ 403,221

The Ottawa Field-Naturalists' Club
Statement of Operations
For the Year Ended September 30, 2003

	2003	2002
REVENUE		
Memberships	$ 14,615	$ 15,488
Trail and Landscape	193	196
Interest	1,339	1,457
GST rebate	780	4,532
Other	617	760
	17,547	22,433
OPERATING EXPENSES		
Affiliation fees	680	680
Computer	302	216
Membership	1,151	1,437
Office Assistant	1,000	1,000
Telephone	1,622	1,848
Insurance	655	655
Audit	1,000	1,000
GST	1,290	1,316
Other	884	2,847
	8,584	10,999
CLUB ACTIVITY EXPENSES		
Awards	–	471
Birds	1,696	223
Education and Publicity	73	1,322
Excursions and lectures	496	164
Macoun Field Club	851	1,027
Soiree	19	466
Trail and Landscape	8,368	9,088
Fletcher Wildlife Garden (Note 4)	2,623	1,294
Other	–	–
	14,126	14,055
	22,710	25,054
EXCESS EXPENSES OVER REVENUE	$ (5,163)	$ (2,621)

The Ottawa Field-Naturalists' Club
Canadian Field-Naturalists — Statement Of Operations
For the Year Ended September 30, 2003

	2003	2002
REVENUE		
Memberships	$ 9,743	$ 10,325
Subscriptions	25,369	28,483
Reprints	9,534	5,608
Publication charges	50,559	16,812
Interest and exchange	7,940	10,404
GST rebate	3,040	3,448
Other	734	339
	106,919	75,419
EXPENSES		
Publishing	$ 80,758	$ 61,570
Reprints	7,307	4,127
Circulation	11,307	7,653
Editing	4,183	2,652
Office Assistant	5,000	5,000
Honoraria	9,000	9,000
GST rebate	6,508	5,146
Other	552	421
	124,615	95,569
EXCESS EXPENSES OVER REVENUE	$ (17,696)	$ (20,150)

The Ottawa Field-Naturalists' Club Notes to the Financial Statements
September 30, 2003

1. CASH

	2003	2002
Chequing	$ (3,777)	$ 5,589
Savings	1,344	58,336
Nesbitt Burns	919	919
Fletcher Wildlife Garden	4,295	5,868
	$ 2,781	$ 70,712

Investment Certificates:	Maturity Value	Maturity Date	Yield	Book Value
	$ 44,385	04/29/04	1.00%	$ 43,764

2. MARKETABLE SECURITIES

Investment Certificates:	Maturity Value	Maturity Date	Yield	Book Value
Province of Newfoundland Coupon	$ 44,782	10/17/11	4.525%	$ 31,421
Province of Manitoba Coupon	29,847	11/15/04	5.119%	26,754
Ontario Savings Bonds	40,000	06/21/05	6.45%	41,370
CMHC Global Debs	52,000	12/01/06	5.250%	53,539
Province of Ontario Bond	30,000	09/12/07	6.125%	31,187
Province of Newfoundland Bond	20,000	10/07/08	6.263%	20,538
Government of Canada Coupon	30,167	12/01/09	5.605%	20,590
Province of New Brunswick Bond	20,000	06/15/10	6.231%	21,068
				$246,467

3. CAPITAL ASSETS
Equipment at a cost of $16,748 is fully amortized.

4. FLETCHER WILDLIFE GARDEN

	2003	2002
REVENUE		
Federal government	$ –	$ 3,059
City of Ottawa	–	1,450
Taverner Cup	1,068	1,354
Sales	–	872
GST	180	398
Donations	50	292
Other	2,425	–
	3,723	7,425
EXPENSES		
Program	2,318	3,174
Backyard	1,362	1,123
Habitats	920	1,864
Interpretation centre	118	783
Administration	944	1,048
Publications	309	337
GST	243	303
Library	132	87
Other	–	–
	6,346	8,719
	$ (2,623)	$ (1,294)

The Ottawa Field-Naturalists' Club Statement of Changes in Net Assets
For the Year Ended September 30, 2003 (Note 5)

Net Assets	Beginning Balance	Excess Expenses CFN	Excess Expenses OFNC	Other Revenue	Expenses	Ending Balance
Unrestricted	$ 80,325	$ (17,696)	$ (5,163)	$ 3,143	$ –	$ 60,609
Club Reserve	100,000	–	–	–	–	100,000
Manning Principal	100,000	–	–	–	–	100,000
Manning – OFNC (a)	1,963	–	–	1,021	1,550	1,434
Manning – CFN (b)	13,179	–	–	4,086	4,112	13,153
Seedathon	2,087	–	–	502	971	1,618
Anne Hanes Memorial	870	–	–	–	–	870
de Kiriline-Lawrence (c)	23,975	–	–	381	5,558	18,798
Macoun Baillie Birdathon (d)	1,327	–	–	10	–	1,337
Alfred Bog (e)	52,274	–	–	3,219	55,000	493
	$ 376,000	$ (17,696)	$ (5,163)	$ 12,362	$ 67,191	$ 298,312

STATEMENT OF CHANGES IN NET ASSETS

a) Manning OFNC Expenses: Taverner Competition, $1,250; Peregrine Watch, $300;

b) Manning CFN Expenses: Vol. 114, No. 2, Douglas Clark, Grizzly Bears in Northern Manitoba $228; Vol. 116, No. 1, Mark Hipfner et al., Common Eiders around Digges Sound $340; Gerald Kuzyk et al., Wolf response to sled dog $160; Kevin White et al., Predation of wolves on wolverines and martens $160; W. A. Fuller, Canada and the buffalo $1,609; Vol. 116, No. 3, John Goold et al., Sperm whale strandings $1,615.

c) de Kiriline Lawrence Expenses: Nature Conservancy of Canada – land in Alfred Bog $4,000; Sierra Club, Ottawa Group – Leitrim Wetlands publicity – $1,000; Greenspace Alliance (Unger) – newspaper ad in defence of South Gloucester Conservation Area $558.

d) Alfred Bog Expense: Nature Conservancy of Canada, $55,000 proceeds from fund raising campaign for acquisition of land in Alfred Bog.

The Ottawa Field-Naturalists' Club Summary of Significant Accounting Policies

September 30, 2003

1. Nature of Business

The organization is non-profit and incorporated under the laws of Ontario (1884). The organization promotes the appreciation, preservation, and conservation of Canada's natural heritage. It encourages investigation and publishes the results of the research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with other organizations engaging in preserving, maintaining or restoring environments of high quality for living things.

2. Financial Instruments

The organization's financial instruments consist of cash, accounts receivable, marketable securities, and accounts payable. Unless otherwise noted, it is the management's opinion that the organization is not exposed to significant interest, currency, or credit risks arising from these financial instruments. The fair value of these instruments approximate their carrying values.

3. Capital Assets

Capital assets acquired after 1989 are expenses. Capital assets acquired prior to 1990 were recorded as assets at cost and amortized on a straight-line basis. These assets have been fully amortized.

4. Statement of Changes in Financial Position

A statement of changes in financial position has not been provided as it would not provide additional meaningful information.

5. Foreign Currency

Transactions during the year in U.S. dollars have been converted in the accounts to Canadian dollars at the exchange rate effective at the date of the transaction. All monetary assets in U.S. dollars at year end have been converted to Canadian dollars at the rate effective on Sept. 30, 2003. Gains or losses resulting therefrom are included in revenue or expenses.

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Please submit, **to the Editor,** in either English or French, **three** complete manuscripts **written in the journal style.** The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Print the manuscript on standard-size paper, **doublespace throughout,** leave generous margins to allow for copy marking, and **number each page.** For Articles and Notes provide a citation strip, an abstract and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in the text or in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Check recent issues (particularly Literature Cited) for journal format. Either "British" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations

Photographs should have a glossy finish and show sharp contrasts. Electronic versions should be high resolution. Photographic reproduction of line drawings, **no larger than a standard page,** are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the journal.

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Limited journal funds are available to help offset publication charges to authors with minimal financial resources. Requests for financial assistance should be made to the Business Manager when the manuscript is accepted.

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Francis R. Cook, Editor
RR 3 North Augusta, Ontario KOG IR0 Canada

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THE CANADIAN FIELD-NATURALIST Volume 118 Number 3 2004

Articles

Notes

(continued on inside back cover)

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The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

Patrons

Her Excellency The Right Honourable Adrienne Clarkson, C.C., C.M.M., C.D.
Governor General of Canada
His Excellency John Ralston Saul, C.C.

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

To communicate with the Club, address postal correspondence to: The Ottawa Field-Naturalists' Club, P.O. Box 35069, Westgate P.O. Ottawa, Canada K1Z 1A2, or e-mail: ofnc@achilles.net.
For information on Club activities telephone (613) 722-3050 or check www.ofnc.ca

The Canadian Field-Naturalist

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Canada

All manuscripts intended for publication except Book Reviews should be addressed to the Editor and sent by postal mail. Book-review correspondence should be sent by e-mail or postal mail to Roy John, Book-review Editor.

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COVER: Lodgepole Pine Dwarf Mistletoe, *Arceuthobium americanum,* growing on Jack Pine, *Pinus banksiana,* Growth in Manitoba. Photograph by Jacques C. Tardif. See article by Epp and Tardif, pages 595-601.

The Canadian Field-Naturalist

Volume 118, Number 4 October–December 2004

Stranding of a Pygmy Sperm Whale, *Kogia breviceps,* in the Northern Gulf of St. Lawrence, Canada

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Measures, Lena, Benoît Roberge, and Richard Sears. 2004. Stranding of a Pygmy Sperm Whale, *Kogia breviceps*, in the Northern Gulf of St. Lawrence, Canada. Canadian Field-Naturalist 118(4): 495-498.

A Pygmy Sperm Whale, *Kogia breviceps*, stranded alive and later died in the Northern Gulf of St. Lawrence, Quebec, Canada on 28 August 2001. This is the northern-most stranding of this species in the western Atlantic. The whale was estimated to be approximately 3 m long and a longitudinal section from one tooth (31 mm long and 5.0 mm in diameter) revealed 3.5 growth layer groups.

Key Words: Pygmy Sperm Whale, *Kogia breviceps,* Gulf of St. Lawrence, Quebec, Canada.

A Pygmy Sperm Whale (*Kogia breviceps*) was found dead 28 August 2001 on the north shore of the Gulf of St. Lawrence. It was observed alive on 27 August by a local resident, Mme Rose-Annette Blais, northwest of St. Charles Island in the Mingan Archipelago National Park Reserve. The whale was observed making slow, undulating movements in shallow water close to shore in Trilobites Bay (50°14'07"N; 63°21' 18"W) and was found dead the next morning on a sandy beach in the bay. Personnel from Parks Canada were alerted and arrived on site to examine the carcass. The whale was estimated to be approximately 3 m long (Figure 1). There were various wounds and lacerations on the rostrum, flanks and abdomen (Figure 2). Two teeth (one broken near the root) collected by Jacques A. Thériault and his father, were later submitted for analysis. Fisheries and Oceans Canada and the Mingan Island Cetacean Study, Inc. were informed of the stranding but before the carcass could be collected for necropsy it had been carried off by a rising tide and was not seen again. Both teeth were deposited in the Maurice Lamontagne Institute collection, Accession Number 11629.

The whale was identified as a Pygmy Sperm Whale based on photographs, approximate length (3 m), the low, falcate dorsal fin located posterior to the center of the dorsum (Figures 1, 2) and size of one intact tooth. The tooth was 31 mm long and 5.0 mm in diameter at its widest point. In the dentine and cementum layers there were 3.5 growth layer groups (GLG) observed in a longitudinal section of the tooth. It is unknown how many GLGs are laid down per year in Pygmy Sperm Whales. If similar to the Sperm Whale *Physeter macrocephalus* [1 GLG = 1 year of age (C. Lockyer, personal communication; Perrin and Myrick 1980)], then this animal is almost 4 years old and likely an adult (Handley 1966). Ross (1984) reported 3.5 GLGs in a sexually mature female that stranded with a calf.

The Pygmy Sperm Whale can be confused with the Dwarf Sperm Whale (*Kogia simus*). The latter is smaller (2.7 m maximum length) with a taller dolphin-like dorsal fin and teeth are less than 30 mm long and less than 4.5 mm in diameter (Handley 1966; Leatherwood and Reeves 1983).

Pygmy Sperm Whales are rarely observed in eastern Canadian waters and have no COSEWIC (Committee on the Status of Endangered Wildlife in Canada) status (Baird et al. 1996). Seven, probably eight, Pygmy Sperm Whale strandings have been reported prior to the present report (Piers 1923; Sergeant et al. 1970; Nelson et al. 1991; McAlpine et al. 1997; Lucas and Hooker 2000) in Canada over the last century, specifically in Halifax and on Sable Island in Nova Scotia, in Blacks Harbour and Saint-John's, New Brunswick and on the French island of Miquelon near the south-

FIGURE 1. Pygmy Sperm Whale beach-cast in Trilobites Bay on 27 August 2001. Length is approximately 3 m.

west coast of Newfoundland. The present report is the northern-most stranding of this species in the western Atlantic and the first within the Gulf of St. Lawrence.

The Pygmy Sperm Whale is a small pelagic, mainly deep-water odontocete (occasionally seen motionless in surface waters) found widely offshore on continental slopes throughout tropical and warm temperate waters in the world. Most information on this species has been obtained from beach-cast carcasses and recently from live-stranded and rehabilitated animals including mother-calf pairs or pregnant females (Hückstädt and Antezana 2001; Scott et al. 2001; Manire et al. 2002). Stomach analyses indicate that the Pygmy Sperm Whale feeds primarily on cephalopods, crustaceans (shrimp, crab) and fish (Reeves et al. 2002). In the western Atlantic most strandings have been reported off the southeastern coast of the United States (Caldwell and Caldwell 1989; Odell 1991) and live individuals have been observed beyond the continental shelf and in the Gulf Stream.

Recently, a rehabilitated Pygmy Sperm Whale equipped with a time-depth recorder was released in the Gulf Stream off the eastern coast of the United States. It was observed for 5 days and remained east of the continental shelf break (200 m isobath) but west of the eastern edge of the Gulf Stream where sea-surface temperatures were 27.8 – 30.0°C (Scott et al. 2001). Unfortunately, dive depth information was not obtained and it is unclear whether the behaviour of this individual reflects that of the species in general.

Odell et al. (1985 as cited in Caldwell and Caldwell 1989) noted that more strandings of *Kogia (K. breviceps* and *K. simus*) occur in Florida when the Gulf Stream shifts farther offshore. They suggested that individuals following prey caught in Gulf Stream eddies or rings that suddenly dissipate may become disoriented and, subsequently, strand. Gulf Stream rings can occur to the north or south of the Gulf Stream but anticyclonic or warm-core rings which are about 1000 m deep and exist on average 4.5 months, drift southwestward to rejoin the Gulf Stream near Cape Hatteras (Richardson 1976; Wiebe 1976). Gulf stream rings have unique physical, chemical and biological characteristics (Wiebe 1976; Joyce and Wiebe 1983; Craddock et al.1992). Although warm-core rings do not ride onto shallow continental shelves, they can push slope water onto the shelf or entrain shelf water into slope waters. Such shelf water entrainment was suggested as providing suitable cephalopod habitat which attracted Sperm Whales in the vicinity of a warm-core ring off Georges Bank (Griffin 1999).

The occurrence of a Pygmy Sperm Whale in the Gulf of St. Lawrence, especially in the northern Gulf, seems unusual as water temperatures are relatively cold [sea-surface temperatures are generally 12 – 18°C in August (Vigeant 1987*)]. The minimum temperature

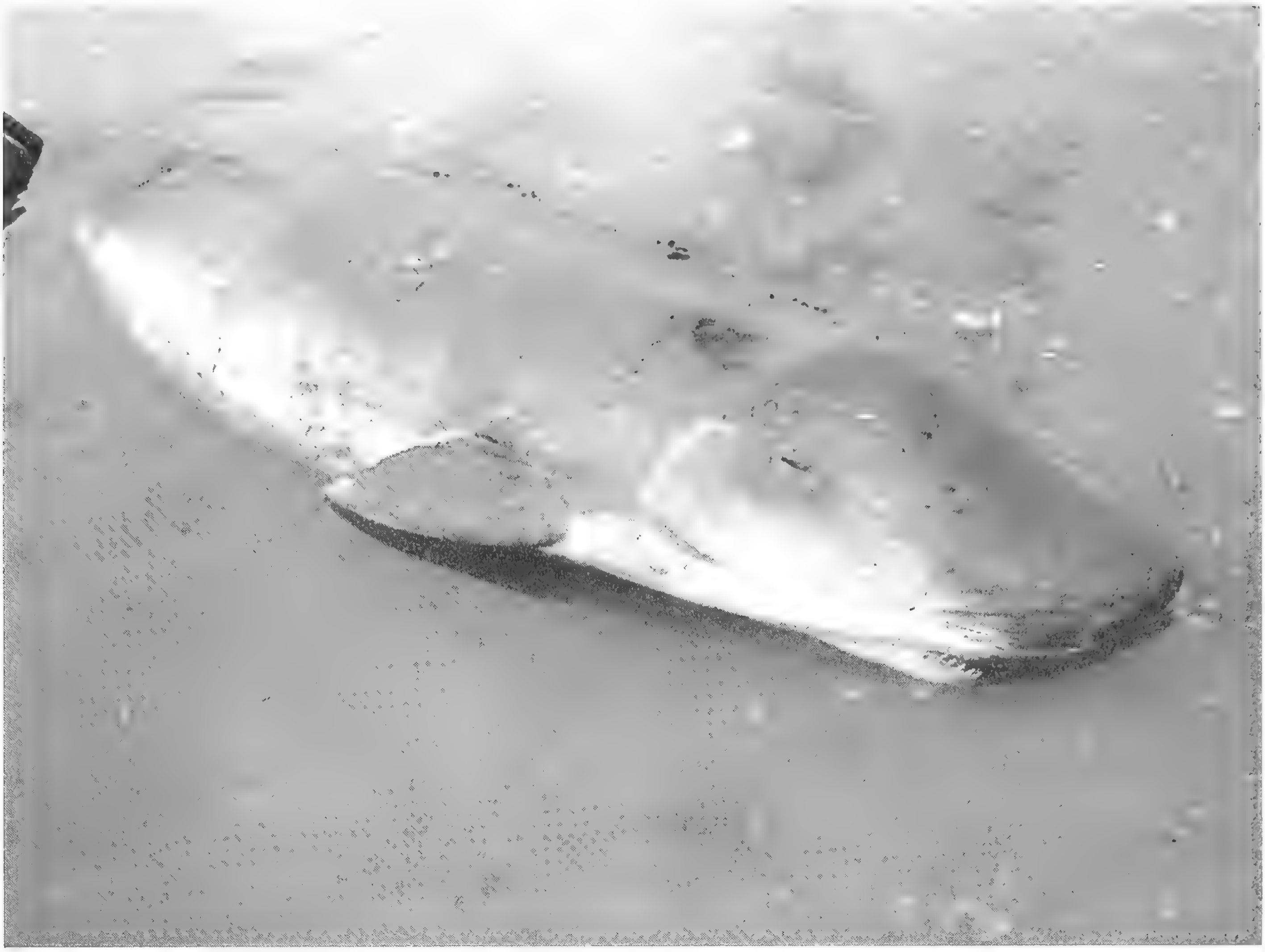

FIGURE 2. Pygmy Sperm Whale in shallow water in Trilobites Bay (same specimen as in Figure 1). Note relative position of dorsal fin on trunk.

tolerated by Pygmy Sperm Whales is unknown. Annual mean air temperatures in most of the northwest Atlantic, especially in the southern Gulf of St. Lawrence, and sea-surface water temperatures throughout eastern Canadian waters in 2001 were generally warmer than normal (Drinkwater et al. 2002a*). In some areas, the upper 30 m in the central and southern Gulf of St. Lawrence show monthly anomalies of 3 - 4°C (Drinkwater et al. 2002b*; Gilbert 2002*). The Pygmy Sperm Whale may have swam and drifted northeast following prey in the Gulf Stream as suggested by Fraser (1974), perhaps using warm-core rings as "stepping-stones" (Peter Wiebe, personal communication) or thermal fronts associated with warm-core rings as observed by Griffin (1999). It may have entered the Gulf of St. Lawrence in warm surface waters on the Cape Breton side of the Cabot Strait when the Cape Breton Current slows in summer (El-Sabh 1977). During a DFO research cruise in the Gulf of St. Lawrence in August 2001 squid (*Illex illecebrosus*) were collected but numbers of specimens collected were not considered exceptional (D. Archambault, DFO, unpublished data).

Acknowledgments

We thank R-A. Blais and J. A. Thériault for assistance in this stranding and providing teeth. We also thank S. Plamondon of Parks Canada who provided photographs and J.-G. Gosselin of Fisheries and Oceans Canada who determined the number of GLGs by cutting the tooth. We appreciate that P. Best and J. Mead examined the photographs and concurred with our identification of the species.

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Seed Dispersal by Brown Bears, *Ursus arctos*, in Southeastern Alaska

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Mammals often consume fleshy fruits and disperse significant quantities of the enclosed seeds. In southeastern Alaska, Brown Bears (*Ursus arctos*) are among the most important dispersers of seeds for the numerous plant species producing fleshy fruits, because these bears are abundant, often eat large quantities of fruit, and commonly excrete seeds in germinable condition. Scat analyses showed that Brown Bears on Chichagof Island ate increasing quantities of fruit through summer and fall. Scats commonly contained several thousand seeds, often of two or more species. Four kinds of seeds of fleshy-fruited plants that normally grow in forest understory germinated at similar levels when experimentally deposited (in bear scats) in the two most common habitats (forest and muskeg), suggesting that habitat distribution of these plants is not determined simply by germination patterns. Although seed passage through bear digestive tracts and the composition of scats are known to affect germination rates to some degree, the most important role of bears in seed dispersal is probably transport.

Key Words: Brown Bears, *Ursus arctos*, Southeastern Alaska, seed dispersal, fleshy fruits, *Rubus*, *Ribes*, *Oplopanax*, *Vaccinium*, *Streptopus*.

Coastal rainforest ecosystems in southeastern Alaska include many shrubs and herbs with fleshy fruits, commonly consumed by vertebrates that disperse the enclosed seeds (Willson 1991; Traveset et al. 2004). Potential dispersal agents include corvids, thrushes, warblers, waxwings, Pine Marten (Hickey et al. 1999) and bears (Willson 1993, 1994). Bears are important dispersers of seeds, because they can consume large quantities of fruit (Welch et al. 1997; Farley and Robbins 1995) and often range over considerable distances (Patten 1993), distributing seeds far from the source. Furthermore, bears are numerous in southeastern Alaska, with density reaching several hundred bears per 1000 km — perhaps as many as 700 or even more in some areas (Miller et al. 1997; J. Whitman, personal communication). The abundance of Brown Bears (*Ursus arctos*) in southeastern Alaska provides an opportunity to examine the consequences of bear frugivory for seed dispersal.

The purpose of this paper is to describe the phenology of Brown Bear frugivory, patterns of scat deposition on a small spatial scale, seed abundance and composition in bear scats, and field tests of seed germination from bear scats. We then integrate this information with previous reports, in order to describe what is known about this ecologically important interaction in southeastern Alaska.

Study Area and Methods

Field work was conducted on northern Chichagof Island in the Alexander Archipelago, at the southern end of Port Frederick (approximately 58°N, 135°30'W). The only bears on this island are Brown Bears. The rainforest is composed chiefly of Sitka Spruce (*Picea sitchensis*) and hemlock (*Tsuga* spp.), with occasional muskegs (bogs) of *Sphagnum* moss, scattered Lodgepole Pines (*Pinus contorta*), and low shrubs. Brown Bear scats were collected from abandoned logging roads, at less than 300 m elevation, in the Neka River valley and near Salt Lake Bay on opposite sides of Port Frederick. During each road survey, all scats were cleared from the road, so that the subsequent survey recorded only scats deposited in the between-survey interval. The roads passed through forests of differing ages, clearcuts, and muskegs.

Seed composition of scats

The frequency of occurrence of seeds, and the principal kinds of seeds present, were recorded in June-September 1990-1993 in 4378 scats. A subset of 570 seed-containing scats was collected in August and September 1990 and 1991, for quantitative estimates of seed abundance. Each of these scats was mixed to distribute the seeds throughout, and a subsample averaging 24% ± 2% (S. E.) of the total scat mass was taken. In the weighed subsample, the seeds were identified to genus and counted; the number of seeds in the entire scat was then estimated by extrapolation. The frequency of seeds in scats through the summer and early fall was examined, using 1 June as Day 1. June scat collections represent the previous spring months; collections in July, August, and September represent only the preceding 30 days, approximately.

Seed germination

In order to compare seed germination in two principal habitats, over 150 of the scats for which total seed content was estimated were placed in two common habitats (muskeg or forest). Scats were "planted" in

transects in each habitat, in whatever microhabitats were available at about 2 m intervals. Muskeg and forest transects near Salt Lake Bay were established in late summer, 1990, and in the Neka Valley in 1991. Seedlings were counted in the planted scats annually (in August) for three (Neka) or four (Salt Lake Bay) years. For seedling censuses, each planted scat was covered with a grid, and seedlings were counted in a random selection of the grid squares. The proportion of grid squares sampled usually ranged from 20% to about 50% of the total scat. Emerging seedlings were counted individually when possible, but so many seeds germinated in some squares that it was impossible to count them without destructive sampling, in which case the abundance of seedlings was estimated visually. The total number of emerging seedlings per scat was extrapolated from this subsample. Curious bears and heavy fall rains disturbed some of the planted scats and thus reduced the usable sample size slightly. Because it was impossible to mark individual seedlings in the very dense clusters, the data are simply estimates of annual germination, not of survivorship of seedlings. Mortality of seedlings was very high and only a few survived more than one year. We did not observe rodent and bird predation on seeds in the experimental transects, although seed predation was sometimes evident in scats on the road system.

The estimated percent of seeds germinating each year was compared between habitats using a repeated-measures ANOVA on arc-sine transformed data (PROC GLM, SAS Systems Inc., Cary, North Carolina). Because the power of this test was low (two sites, two habitats), our results were re-examined, to see if the outcome was merely a result of the few degrees of freedom in the ANOVA. For this we used a t-test (in which the planted scats were the replicates, so there were more degrees of freedom in the test) to test for differences in seedling germination between habitats for the first and the last years at each site (no seedlings in the censused grid squares survived for the entire length of the experiment).

Results

Phenology of fruit consumption

Scats collected in early summer contained mostly vegetable fiber and occasional deer remains (hair, bone, hoof) with few seeds, as expected, because few fruits are available at that time of year (some overwintered

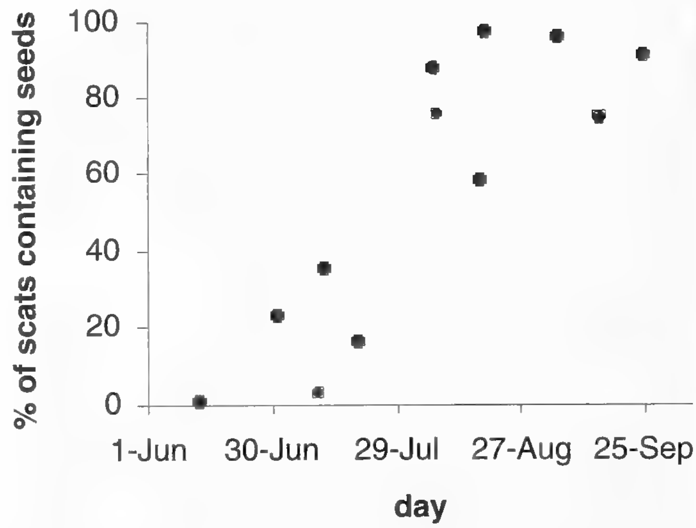

FIGURE 1. Seasonal changes, for four years, in the percent of bear scats containing seeds, Chichagof Island, southeastern Alaska. $R_s = 0.79$, $p < 0.001$.

Viburnum and *Maianthemum*; some early *Rubus spectabilis*). The frequency of seed-containing scats increased through the summer, from less than 1% in mid-June to over 90% in late August and early September ($R_s = 0.79$, $p < 0.001$, $n = 12$; Figure 1).

Scat distribution at a small spatial scale

In addition to widespread deposition of scats on the landscape (Patten 1993), defecations by a moving bear can spread multiple deposits of a single defecation over several meters, which could be ecologically important. A survey of 1163 "scat trails" revealed that 42% were multiple deposits, with 3% of them comprised of over 20 separate droppings spread over as much as 84 m.

Seed composition in scats

Seeds were identified at least to genus; in some cases, the genus was represented by only one species in this area (*Sambucus racemosa*, *Rubus spectabilis*, *Oplopanax horridum*). In the case of *Ribes*, the species was most likely *bracteosum*, which grew commonly in this area. Likewise, *Streptopus amplexifolius* was far more common in this area than two congeners. Both *Vaccinium ovalifolium* and *V. alaskense* were present and were not distinguishable in the scats. The most commonly occurring seeds were *Oplopanax*, *Vaccinium*, *Ribes*, *Rubus*, and *Streptopus* (Table 1).

Seeds had a high probability of being deposited not only with numerous conspecifics but also with at

TABLE 1. Summary of frequency of occurrence of common kinds of seeds in scats on northern Chichagof Island. Data are the number of months that the frequency of occurrence equaled or exceeded the stated value.

	Kind of seed				
	Vaccinium	*Ribes*	*Oplopanax*	*Rubus*	*Streptopus*
Number of months ≥ 20%	5	4	5	1	1
Number of months ≥ 50%	3	1	3	–	–

TABLE 2. Average (S.E.) number of seeds per scat on northern Chichagof Island. N = 570 scats.

Year	Month	Kind of seed					
		Vaccinium	*Ribes*	*Oplopanax*	*Rubus*	*Streptopus*	*Sambucus*
1990	July	3581 (667)	914 (767)	52 (18)	383 (91)	–	–
	August	4655 (461)	700 (165)	134 (22)	723 (182)	30 (8)	126 (42)
	September	2534 (468)	1918 (281)	360 (42)	830 (291)	41 (15)	88 (33)
1991	July	4375 (933)	2817 (–)	63 (25)	650 (137)	47 (26)	–
	August	7193 (760)	364 (109)	228 (40)	583 (120)	81 (20)	–
	September	4329 (795)	1302 (293)	374 (76)	54 (20)	56 (12)	683 (606)
		4445	1971	231	634	51	110
$\bar{x}$ number of seeds/fruit*		47	12	2	42	22	3
$\bar{x}$ number of fruits		95	89	116	15	2	37

*from Traveset et al. 2004.

least one other kind of seed: in monthly samples, a median of 60% (range 16-87%) of scats contained at least two kinds of seeds, and sometimes as many as five kinds. *Vaccinium* and *Ribes* were consistently the most abundant seeds in scats collected (Table 2). In most months, *Rubus* was next most abundant, followed by *Oplopanax* and others. The maximum numbers per scat for each of the genera listed in Table 2 were approximately 37 000 *Vaccinium*, 14 500 *Ribes*, 7600 *Rubus*, 2000 *Oplopanax*, 1900 *Sambucus*, and 400 *Streptopus*. In addition to those represented in Table 2, other kinds of seeds appeared in the scats sporadically (from fleshy fruits, *Viburnum*, *Maianthemum*; non-fleshy fruits, *Kalmia*, *Heracleum*, *Carex*, grass).

Because the number of seeds per fruit differs greatly among genera (Traveset et al. 2004), the approximate number of consumed fruits of each type per scat differs markedly from the abundances of seeds (Table 2). The average scat represented only approximately 89 – 116 fruits of the most commonly consumed types.

Seed germination

Germination patterns were examined only for *Vaccinium*, *Ribes*, *Rubus*, and *Oplopanax*. A few *Vaccinium* seeds germinated in the year they were planted (<1% of all seeds estimated to be present); germination levels were generally low (<6%) over the next four years (Table 3). Annual germination of *Oplopanax* was also rather low (≤18%). In contrast, both *Ribes* and *Rubus* germinated relatively well (up to 31-34% per year), with the highest levels of germination often in the second year after planting. All these kinds of seeds were clearly capable of dormancy for at least four years.

There were no differences in germination percentages between habitats for any species (ANOVA; range of p-values: 0.17 – 0.82). The subsequent exploratory t-test also revealed no differences between habitats except for *Vaccinium* in one site – one statistically significant outcome in 16 tests, which might happen by chance alone. Variation among scats planted within a habitat was relatively large, but it probably reflected the biological reality of variation on a small spatial scale.

Discussion

Bears are well-known frugivores, consuming many species of fleshy fruits (Auger et al. 2002; Willson 1993). Fruits can be an important resource for preparing for winter dormancy and lactation (females give birth in winter dens), and berry-crop failures can lead to lower reproductive success (Rogers 1987). Bears can consume many kilograms of fruits in a day (Welch et al. 1997; Farley and Robbins 1995). Although a single bear scat in the present study often contained thousands of seeds, this represented relatively few fruits and therefore only a small proportion of possible daily consumption.

Composition of the fecal deposit can affect seed germination and seedling growth (Traveset et al. 2001), and the concentration of seeds in scats can lead to post-dispersal seed predation and secondary dispersal via scattering (Bermejo et al. 1998). Germination of seeds passed by captive bears was generally similar to or faster than that of seeds extracted from fruits by researchers, although germination of some species was quite low in all conditions and was sometimes dependent on the substrates on which the seeds happen to land (Traveset and Willson 1997, 1998). But rapid germination is not necessarily beneficial, if seed dormancy is indeed an adaptation for dispersal in time.

The most important consistent effects of frugivory by bears on seed dispersal may be transport, rather than shifts of germination behavior of seeds passed through the digestive tract. In a companion study, the probability of seed deposition by Brown Bears on Chichagof Island was greatest at 600-900m from a source (Patten 1993). The greatest distance estimated for seed transport by Brown Bears was over three km (Patten 1993), and even though few seeds are likely to be carried this far from their source, the extended tail of the seed distribution pattern can be disproportionately important for dispersal ecology (Portnoy and Willson 1992) and plant community ecology (Vellend et al. 2003). Little habitat preference was shown by the bears tracked on Chichagof, except for an avoidance of bare-rock areas, so the probability of seed deposi-

TABLE 3. Estimated average percent of seeds germinating per year in two common habitats at two sites on Chichagof Island, southeastern Alaska.

Site	Habitat	Year	Kind of seed							
			Vaccinium		*Ribes*		*Oplopanax*		*Rubus*	
Neka	Forest	1992	3.9	(0.9)	0.2	(0.2)	<0.1	–	22.5	(7.2)
	n = 30	1993	2.8	(0.5)	30.8	(15.7)	18.4	(10.1)	28.5	(9.8)
		1994	3.3	(0.9)	14.7	(9.0)	9.5	(4.9)	13.6	(4.8)
	Muskeg	1992	5.9	(2.2)	–		1.1	(1.0)	20.7	(7.7)
	n = 30	1993	2.9	(1.0)	–		10.2	(8.4)	19.7	(7.5)
		1994	1.2	(0.4)	–		11.0	(10.6)	5.6	(3.3)
Salt Lk Bay	Forest	1991	2.4	(0.9)	19.1	(11.5)	5.3	(2.1)	17.0	(9.3)
	n = 60	1992	3.6	(0.8)	30.8	(16.2)	1.6	(0.8)	34.2	(8.7)
		1993	1.8	(0.3)	2.5	(1.5)	1.1	(0.5)	19.7	(6.9)
		1994	1.3	(0.2)	1.0	(0.6)	3.0	(1.3)	9.8	(4.8)
	Muskeg	1991	1.1	(0.5)	0.5	(0.5)	4.6	(2.7)	7.1	(5.1)
	n = 49	1992	3.0	(1.0)	25.6	(10.4)	1.2	(0.7)	19.6	(6.9)
		1993	1.8	(0.7)	6.3	(5.2)	0.9	(0.7)	10.7	(4.5)
		1994	1.6	(0.8)	0.3	(0.2)	0.6	(0.4)	4.3	(3.0)

tion was proportional to habitat availability, including logged areas (Patten 1993). Because forest was the common habitat, this meant that the forest fruits, such as most of the species examined here, had a fairly high probability of deposition in the appropriate habitat (Patten 1993). On a smaller scale, defecation by moving bears could increase the probability that seeds from one defecation episode are deposited in more than one habitat or microhabitat, as well as decrease the intensity of seedling competition.

Germination of several forest and forest-edge species was similar in forest and muskeg, indicating that habitat distribution of these shrubs is not determined by germination requirements at the habitat scale. The large variances of the estimates of germination level not only decreased the probability of detecting habitat differences, but they also suggest that microhabitats of seed deposition may be more important in determining germination success than habitats. Mortality of seedlings was very high, in part an apparent result of desiccation during periods of warm, sunny weather. Especially at high densities, intra- and interspecific competition was undoubtedly intense and probably contributed to seedling mortality. However, occasionally small groups of seedlings persisted and were still alive when field work ended; similar "bear gardens" were also found in natural settings (Willson 1994).

Bears are good seed dispersers: they commonly transport germinable seeds up to hundreds of meters from a source, often in appropriate habitat, simultaneously with a load of fertilizer that may influence germination and growth. Although scats containing numerous seeds produce conditions of high seedling competition, several factors tend to reduce the impact of competition on the effectiveness of dispersal. Germination may be spread over several years. Relatively rapid passage through the gut and multiple defecations per day within a bear's home range spread scats over the landscape. Scat trails of moving bears spread out the seeds on a more local scale. Bears may be more reliable dispersal agents for many kinds of seeds than most frugivorous birds in this area, since the coastal region is not a major flyway for migratory forest birds.

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A Mapping of the Present and Past Forest-types of Prince Edward Island

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Sobey, D. G., and W. M. Glen. 2004. A mapping of the present and past forest-types of Prince Edward Island. Canadian Field-Naturalist 118(4): 504-520.

Our aim was to produce maps showing the distribution on Prince Edward Island of five forest-types previously identified from a TWINSPAN analysis of ground flora data collected at 1200 sampling points in a field survey. For this purpose we had available two databases: one on the composition of the tree canopy of 82 957 forest stands, as determined by photo-interpretation of a 1990 aerial photographic survey of the island; the other on the drainage properties of the same stands from a published soil survey. The tree canopy and drainage criteria for sorting these stands into five stand-types were chosen in the light of the equivalent properties of the TWINSPAN forest-types as evident from the field survey. These criteria were perfected in four trial computer-sortings, followed by the computer-printing of maps showing the distribution of the stand-types. These maps, which were then evaluated by comparing them with the properties of the TWINSPAN forest-types, are the first fine-scale maps of the main forest-types of the island. They reveal that, of the three "primary" forest-types, the upland hardwood forest occurs especially in the central and south-eastern hill-lands, as well as in scattered parcels elsewhere, whereas the Black Spruce forest and the wet species-rich woodland occur primarily in areas of lower elevation in the east and west of the island. The two forest-types resulting from human disturbance, the White Spruce woods and the "disturbed forest", have a more scattered distribution, with the White Spruce woods being found especially in the central and eastern parts of the island and the disturbed forest in the west and east of the island. A secondary aim was to map the conjectured distribution before European settlement of the three primary forest-types: two maps have been produced, one showing the distribution of upland hardwood forest, the other of the wet forest-types.

Key Words: forest classification, forest mapping, forest history, Prince Edward Island.

Between 1990 and 1992 the Prince Edward Island Forestry Division carried out a comprehensive Forest Biomass Inventory of the province, a component of which was a field survey in 1991 at 240 randomly-selected forest sites. At each of the sites the percentage cover of the ground flora species in 4-m^2 plots was recorded at five sampling points. The availability of such ground flora data from such a large number of plots (1200 in total) presented an unprecedented opportunity for the study and analysis of the woodland ground vegetation and forest-types of Prince Edward Island.

An earlier paper (Sobey and Glen 2002) presented an analysis of the ground flora data in 1127 of the plots using two multivariate techniques: TWINSPAN – two-way indicator species analysis (a classification technique), and DECORANA – detrended correspondence analysis (an ordination technique). TWINSPAN led to the recognition of five forest-types, each characterized by particular tree species and soil drainage properties: (1) a wet species-rich swamp-type woodland, (2) upland hardwood forest, (3) Black Spruce (*Picea mariana*) forest, (4) old field White Spruce (*Picea glauca*) woods, and (5) disturbed conifer-dominated forest. It was conjectured that the first three of these forest-types were heavily modified descendants of forest-types occurring at the time of European settlement, while the two latter appeared to be largely the product of successional processes associated with the effects of human disturbance and forest clearance. The DECORANA ordination provided further support for the overall importance of soil drainage and human disturbance as the principal factors responsible for the differences between the five forest-types.

The aim of this paper is to expand the results of the plant community analysis beyond the 1200 sampling points to include the whole forested area of the island, in the form of maps showing the total distribution of the five forest-types on the island. Since the forest-types were initially segregated and defined by TWINSPAN on the basis of the composition of their ground flora, the ideal mapping approach would have been to use the ground flora composition of all forest stands on the island as the basis for mapping the distribution of the forest-types. However, such data are not available for the whole forested area of the island and are never likely to be. The forest-types thus had to be mapped using data that showed a correlation with the ground flora composition (i.e., data on the composition of the tree canopy) and also for some, data on soil drainage properties. It is fortunate that there were available two comprehensive relevant databases for the

whole island: the more important was a database on the tree species composition of all forest stands on the island, based on an aerial photographic survey carried out in mid-summer 1990; the other was the Prince Edward Island Soil Survey (MacDougall et al. 1988) which classified the soils of the island into 44 soil series and mapped their distribution (at a scale of 1:10 000) over the whole island. The soil survey proved useful in the forest mapping because some of the TWINSPAN forest-types had high levels of association with particular soil drainage properties.

It should be noted that none of the previous attempts at forest classification and mapping that include Prince Edward Island (Stilgenbauer 1929; Halliday 1937; Rowe 1959; Loucks 1962) aimed to map what was actually present on specific sites, nor do they contain a high level of detail or accuracy. Halliday's and Rowe's maps, being part of national studies, show no internal differentiation at all in the forests of the island. Loucks (working at the level of Maritime forests), did subdivide the island's forests: he placed them in three "forest districts" but the boundaries of these are very generalized on his map. One comprised the hardwood areas of the central and eastern parts of the island; the other two were coniferous districts: one in the west along the shores of Northumberland Strait, the other running along the length of the northern shore. The map showing the greatest detail (Stilgenbauer 1929) is actually the earliest of the four, but Stilgenbauer's descriptions of his "forest belts" are brief and qualitative and the criteria he used for delimiting them are not given. In addition to these mapping studies, there is a useful descriptive summary of the forest-types of the island in Erskine (1960), and in Appendix 1 the stand-types emerging from this study are equated with Erskine's descriptions.

The principal objective of this study was thus, making use of two comprehensive databases, to map the total distribution on Prince Edward Island of the five forest-types recognized in a TWINSPAN analysis, and to further verify the validity of the maps by comparing the properties of the mapped stands with those of the TWINSPAN forest-types. Such a mapping will not only give us a clear picture of the current actual distribution on the ground of the main forest-types on the island, but should also assist us in understanding the factors responsible for their distributions. A secondary objective (on the basis of any stand and soil relationships that might emerge) was to attempt to extend the mapping back into historical time in order to obtain a picture of the possible distribution of the forest-types before the advent of the large scale forest clearance that began in the eighteenth century with the beginning of European settlement on the island.

Methods

The methodology leading to the description of the forest-types and their mapping makes use of several large independently obtained databases and involves a number of different stages in processing and analysing the data they contain. Figure 1 shows these databases and stages in diagrammatic form. The end-product, computer-produced maps of the five forest-types, is the result of a computer-sorting of 82 957 demarcated stands of "high forest" (i.e., excluding alder woods, plantations, clear-cut and burned areas) into five forest-types on specific tree canopy and soil drainage criteria. In the description of the various steps in the analysis, the text that follows is linked to the stages shown in Figure 1 by Roman numerals in square brackets, e.g.: **[I]**.

The databases:

1. The 1991 field survey: ground flora and tree canopy data

Of the vast amount of data collected at the 1200 sampling points in the 1991 field survey, two data sets, one on the ground flora **[II]**, the other on the tree canopy **[III]**, are of relevance to this report. We present here only a summary of the methods used to collect these data – full field methods are given in Sobey and Glen (2002).

The data were collected between June and September 1991 at 1200 ground flora plots located at 240 randomly-selected forest sites. At each sampling point the tree canopy was assessed using a "point sampling" technique involving the use of a "variable-radius plot" centred on the sampling point (Watts 1983). From these field data, the percentage contribution of each tree species to the total woody biomass (to the nearest 10%) in each variable radius plot was calculated **[III]**. The ground flora species were assessed within a circular 4-m^2 plot, with each species being given a percentage cover value to the nearest 10%, with a minimum value of 5% **[II]**.

The TWINSPAN classification and the recognition of five forest-types

The TWINSPAN classification of 1127 of the 1200 ground flora plots (based on the species composition and percentage cover of their ground flora species) resulted in the recognition of 11 ground flora plot groups or community-types **[V]** (see Sobey and Glen (2002) for a full description of the methodology – note that 73 plots were omitted from the analysis either because no trees were recorded in the area of the sampling point, or because no ground flora species were present in the 4-m^2 plot). These plot groups were then examined in terms of the species composition of the tree canopy and other properties at the sampling sites (especially soil drainage), and as a result five major forest-types were recognized **[VII]**. (See Sobey and Glen (2002) for summary descriptions of each of these forest-types and maps showing the distribution of their sampling points on the island.)

2. The 1990 aerial survey: the forest stand database

Complete aerial photographic coverage of the island was carried out in mid-summer 1990 as part of

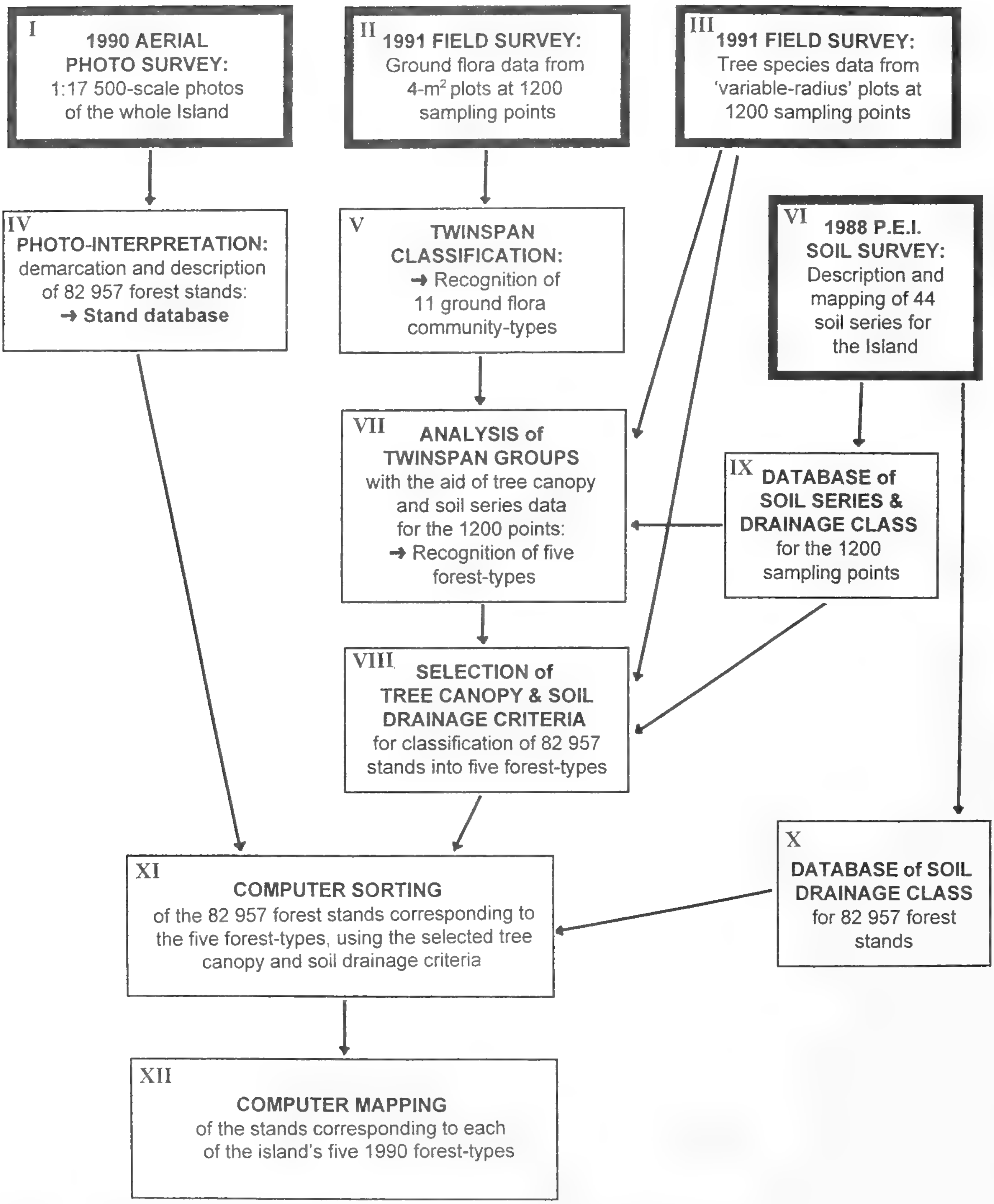

FIGURE 1. The stages leading to the mapping of the 1990 forest-types on Prince Edward Island: a flow diagram showing the databases used (in the boxes with heavy borders) and the analyses carried out.

the 1990-1992 Prince Edward Island Forest Biomass Inventory [I]. The false-colour infra-red photographs resulting from the survey (scale *c.* 1:17 500) were analysed by trained photo-interpreters in the Forestry Division with the purpose of dividing the total forested area into "stands" which were then recorded on a map as "polygons" [IV]. For the purpose of the photo-interpretation, a stand was taken to be a group of trees having a relatively uniform visual appearance from the air as evident in the aerial photograph. Stands could comprise a single species or several or many species, but they are generally of a uniform species composition, height and density. For each of the 82 957 stands, up to five tree species, each con-

FIGURE 2. The distribution of "high forest", based on photo-interpretation of the 1990 aerial photographic survey of the island. (High forest excludes Speckled Alder woods, plantations, and clear-cut and burned areas.)

tributing greater than 5% crown closure to the canopy, were recorded, with the percentage contribution of each species being estimated to the nearest 10%. The database resulting from the photo-interpretation was computerised, and the stand boundaries were linked to the Geographic Information System (G.I.S.) for the province, enabling the direct plotting onto maps of stand boundaries and areas, as well as the extraction of data on their tree species make-up.

3. The 1988 soil survey of Prince Edward Island: a soil series database

The most recent major soil survey of the island (MacDougall et al.1988) has resulted in the classification of the island's soils into 44 soil types or "series", and the mapping (scale: 1:10 000) of the distribution of these series over the whole island **[VI]**. The soil maps have been digitized in the G.I.S. for the island, such that the soil series at each of the sampling points in the 1991 field survey **[IX]**, as well as for each forest stand polygon in the aerial stand database **[X]**, are accessible by computer. For this study it was decided that it would also be useful to group the 44 soil series into six drainage classes: rapidly-drained, well-drained (coarse-textured parent materials), well-drained (medium-textured parent materials), imperfectly-drained, poorly-drained, and organic soils.

Selection of the tree canopy and soil drainage criteria.

The selection of the criteria for dividing the 82 957 stands of high forest (i.e., the area shown in Figure 2) into the five forest-types **[VIII]** (or "stand-types" as they will be termed to distinguish them from the TWINSPAN-defined forest-types), was based on the tree canopy and soil drainage properties of the five TWINSPAN forest-types as evident from the 1991 field survey (Sobey and Glen 2002). Four trial computer sortings on selected criteria were carried out in succession; the results of each trial were evaluated and the criteria for each of the five stand-types were then redefined and a new sorting was carried out. Eventually the perfected criteria were chosen (Table 1), and all of the stands in the database were computer-sorted on these criteria **[XI]**, followed by the computer-printing of maps showing the distribution of each stand-type on the island **[XII]**. It should be noted that in any of the sortings the order of the sort (i.e., of the selecting and removal of each stand-type) is important, since once a stand has been sorted it is normally no longer available for inclusion in subsequent stand-types even if it should meet their particular criteria. The following is a more detailed discussion of the criteria used for each of the five forest-types, as well as of some of the changes made as a result of the trial sortings:

1. Upland hardwood forest. In the TWINSPAN classification Sugar Maple (*Acer saccharum*) and American Beech (*Fagus grandifolia*) had been virtually restricted to sampling points belonging to the upland hardwood forest-type (Sobey and Glen 2002). Yellow

TABLE 1. The criteria used in the sorting of 82 957 stands of "high forest" on Prince Edward Island into five stand-types corresponding to the five forest-types recognized in a TWINSPAN classification of 1127 ground flora plots.

Criteria	Stand-type
SELECT AND REMOVE: stands designated as clear-cut, burned, plantation, windfall, or alder. This leaves 82 957 stands of "high forest"	
FIRST SORT: Excluding any stands containing White Ash, Eastern White Cedar or White Elm, select all stands containing Sugar Maple, American Beech or Eastern Hemlock, plus all stands with Yellow Birch, but for the last species excluding those stands on poorly-drained, imperfectly-drained or organic soils.	**1. Upland hardwood forest**
SECOND SORT: Excluding any stands containing White Ash, Eastern White Cedar or White Elm, select all stands containing Black Spruce with crown closure ≥ 50%.	**2. Black Spruce forest**
THIRD SORT: Select all stands containing White Elm, White Ash, or Eastern White Cedar, and/or classed as 'swampy', plus all stands with a crown closure of total hardwoods ≥ 50% and occurring on poorly-drained or imperfectly-drained soils.	**3. Wet rich woodland**
FOURTH SORT: Select all stands containing White Spruce with crown closure ≥ 40%.	**4. White Spruce woods**
RESIDUAL STANDS:	**5. "Disturbed forest"**

Birch (*Betula alleghaniensis*) had a somewhat wider distribution, also occurring at a rather high level at wet rich woodland sampling points. In the initial trial sortings all stands containing any presence of Sugar Maple, American Beech and Yellow Birch were selected; however, for the final sorting it was decided to exclude those stands selected due to the presence of Yellow Birch that occurred on poorly-drained, imperfectly-drained or organic soils, soils more characteristic of wet rich woodland than of upland hardwood forest. Also, in the final sort, Eastern Hemlock (*Tsuga canadensis*) was included as a selecting species, and stands containing American Elm (*Ulmus americana*), Eastern White Cedar (*Thuja occidentalis*) and White Ash (*Fraxinus americana*), all characteristic of wet rich woodland, were specifically excluded.

2. Black Spruce forest. The problem in segregating stands of this forest-type was choosing a minimum percentage crown closure for Black Spruce. Since the mean percentage woody biomass contribution of Black Spruce at the Black Spruce forest sampling points was 53.1% (Sobey and Glen 2002), it was decided to set both a high value and also one that made ecological sense: the criterion used in the final sort was that for a stand to be assigned to Black Spruce forest, at least 50% of its canopy had to be Black Spruce. From the earlier trial sortings it had also become evident that it was necessary to exclude any stands containing American Elm, White Ash or Eastern White Cedar, species virtually absent from this forest-type.

3. Wet rich woodland. In the early trial sortings an attempt was made to select stands of this forest-type on the percentage crown closure of its most important tree species: Red Maple (*Acer rubrum*) – a minimum crown closure of ≥ 25% was set. However, the problem was that Red Maple was also present at high levels in the still unsorted "disturbed conifer-dominated forest". It was thus decided to make use of the fact that 80.2% of the sampling points of the TWINSPAN wet rich woodland occurred on imperfectly- and poorly-drained soil series (Sobey and Glen 2002). In the end the criterion used was firstly to select all stands containing the minor tree species diagnostic of this forest-type (as evident in the TWINSPAN classification): i.e., White Ash, American Elm and Eastern White Cedar, as well as all stands classified as "swampy" by the photo-interpreters. Then, since an overall factor distinguishing the TWINSPAN wet rich woodland sampling points from the disturbed conifer-dominated forest was a higher level of total hardwoods (Sobey and Glen 2002), we selected all stands with a minimum total hardwood crown closure of 50%, in combination with a requirement that all such stands be on poorly- and imperfectly-drained soils.

Having selected the stands that appear to be derived from pre-European settlement forest-types, the next step was to separate the remaining stands into the two types of successional and disturbed forest: i.e., White Spruce woods and disturbed conifer-dominated forest.

4. White Spruce woods. Here it was a matter of selecting the minimum percentage crown closure of White Spruce for a stand to be assigned to White Spruce woods. Given the fact that the *mean* percentage contribution of White Spruce to the woody biomass of TWINSPAN White Spruce woods sampling points was 62.2 % and in the disturbed conifer-dominated forest it was 16.7% (Sobey and Glen 2002), a middle level (40%) was chosen.

5. Disturbed conifer-dominated forest (or simply "disturbed forest"). The residual stands should by default correspond to the remaining TWINSPAN forest-type (disturbed conifer-dominated forest), even if

TABLE 2. The number of hectares and stands (also as percentages) assigned to each stand-type in the computer-sorting. A percentage breakdown of the stand area by drainage class is also given, as is its status in 1935 as either forest-covered or cleared land as determined from a 1935 aerial photographic survey of the whole island. (In brackets after the forested percentage is the equivalent parameter for the TWINSPAN forest-type sampling points of the 1991 field survey – those bolded are within ± 20% of the stand value.)

	STAND-TYPES					
	Upland Hardwood Forest	Black Spruce Forest	Wet Rich Woodland	White Spruce Woods	Disturbed Forest	TOTALS
HECTARES	55 043	33 106	42 192	57 982	65 259	253 582
Percentage of area	21.7	13.1	16.6	22.9	25.7	100
NUMBER OF STANDS	16 170	8 049	13 863	22 709	22 166	82 957
Percentage of stands	19.5	9.7	16.7	27.4	26.7	100
DRAINAGE CLASS (% of area)						
Organic	0.04	6.8	0.78	0.58	0.86	1.4
Poorly-drained	5.8	54.8	70.1	11.6	14.5	25.8
Imperfectly-drained	3.9	16.8	24.6	8.1	7.8	10.7
Well-drained (medium)	2.7	1.1	0.74	2.8	5.0	2.4
Well-drained (coarse)	74.4	9.0	2.2	48.3	46.2	35.6
Rapidly-drained	12.9	10.2	1.3	27.3	24.1	14.9
Unclassified	0.28	1.3	0.18	1.2	1.5	0.93
STATUS in 1935 (% of area)						
Forested	93.8	77.2	75.8	37.6	67.4	69.0
	(86.4)	**(67.5)**	**(79.5)**	(24.4)	**(74.2)**	**(69.5)**
Cleared land	6.2	22.8	24.2	62.4	32.6	31.0

all are not in fact dominated by conifers. In the trial sortings an additional fifth sort was carried out in order to separate out the residual stands that were indeed conifer-dominated. This was done by sorting on a minimum *conifer* crown closure of ≥ 50% – this selected 42% of the residual stands. The other group was thus termed "disturbed *hardwood*-dominated forest", i.e., comprising residual stands with hardwoods > 50% crown closure. However, in the end, the distinction between hardwood and softwood domination in the residuals was not considered important and these stands have been simply termed "disturbed forest".

Results

Table 2 presents the results of the final computer sorting, expressed in terms of the area in hectares and the number of aerial stands assigned to each stand-type, both also expressed as percentages. Table 2 also gives a breakdown of the soil drainage classes for each of the stand-types and their status in 1935 (as "cleared land" or "forested"), as determined from analysis of the earliest aerial photographic survey of the island (see Glen 1997). The tree species make-up of the five stand-types is shown in Table 3 and the computer-printed maps showing their distribution on the island are shown in Figures 3 to 7.

In the sorting, the 1990 "high forest" of the island was divided into five stand-types – see Appendix 1 for summary descriptions of each of these stand-types. These fall naturally into two groups, each of which occupies about half of the island's forested area: (1) the three stand-types which appear to be recognizable descendants (even if heavily-modified) of pre-European settlement forest-types (upland hardwood forest, Black Spruce forest and wet rich woodland) – these make up 51.4% of the area under high forest; (2) the two other stand-types (old field White Spruce woods and "disturbed forest"), representing more disturbed and/or successional types not likely to have been important in the pre-European forest – these make up the other 48.6%. It is likely that before the period of European settlement, land surfaces now under these two latter stand-types would have been covered by one of the three "primary" stand-types.

Evaluating the validity of the stand-types

One way of assessing the validity of the products of the sorting is to compare, as in Table 3, the tree species composition of each stand-type (in the form of percentage crown closure) with the equivalent parameters of the corresponding TWINSPAN forest-type: the percentage contribution to woody biomass in the 1200 variable-radius plots of the ground survey, and the contribution of each of the tree species to the percentage crown closure in those stand polygons in which the 1200 variable-radius plots were located. Another way to assess the validity of the sorting is to compare the drainage properties and the status in 1935 of the aerial stand-types with those of the TWINSPAN-based forest-types (Tables 2 and 4). The data required for these comparisons were extracted using the Database program "FoxPro" from the 1991 field survey database

TABLE 3. The mean percentage crown closure (± S.E.) of the principal tree species in each stand-type (based on *all* the stand-polygons of each stand-type including those in which the species was not recorded). To enable comparison of these values with the equivalent parameters for the TWINSPAN forest-types, placed below in round brackets is the mean percentage contribution (± S.E.) of each tree species to the total tree biomass in the variable-radius plots of the corresponding TWINSPAN forest-type; and in square brackets the mean percentage crown closure of the tree species (± S.E.) in those stand-polygons in which the variable-radius plots were located. For crown closure values (unbracketed) > 10%, a bolded percentage within the brackets indicates that there is "good agreement" between the two values (i.e., the bracketed value lies within ± 20% of the unbracketed value), while an italicized bolded percentage indicates a "notable discrepancy" between the two values (i.e., the bracketed value is > ± 50% of the unbracketed value); where crown closures (unbracketed) were < 10%, the differences were assessed subjectively on the basis of their relative magnitudes.

	STAND-TYPES					
	Upland Hardwood Forest	Black Spruce Forest	Wet Rich Woodland	White Spruce Woods	Disturbed Forest	**ALL STANDS (All 1200 plots †) [All 1200 sampling point stands]**
CONIFERS:						
Picea mariana	0.22 ± 0.020	71.4 ± 0.18	9.9 ± 0.13	1.1 ± 0.034	5.3 ± 0.079	10.4 ± 0.080
	(**0.72 ± 0.35**)	(53.1 ± 4.9)	(3.8 ± 1.2)	(4.3 ± 1.5)	(10.1 ± 1.4)	(5.4 ± 0.57)
	[**0.79 ± 0.28**]	[39.6 ± 3.8]	[**13.3 ± 1.7**]	[4.1 ± 1.1]	[12.4 ± 1.3]	[**9.1 ± 0.59**]
Picea rubens	0.59 ± 0.032	0.69 ± 0.042	2.9 ± 0.072	0.47 ± 0.021	7.1 ± 0.096	2.7 ± 0.036
	(**0.88 ± 0.27**)	(***17.3 ± 3.8***)	(0.51 ± 0.30)	(***4.6 ± 1.2***)	(**7.1 ± 1.2**)	(**2.8 ± 0.32**)
	[**0.98 ± 0.28**]	[3.3 ± 1.2]	[5.4 ± 1.1]	[3.0 ± 1.1]	[3.6 ± 0.66]	[**2.6 ± 0.28**]
Picea glauca	4.8 ± 0.086	1.6 ± 0.068	8.2 ± 0.11	68.1 ± 0.13	10.4 ± 0.078	24.2 ± 0.11
	(8.6 ± 0.92)	(***7.2 ± 2.3***)	(***18.0 ± 2.2***)	(**62.2 ± 3.4**)	(***16.7 ± 1.5***)	(17.0 ± 1.0)
	[10.3 ± 0.94]	[***25.1 ± 3.4***]	[**7.3 ± 0.98**]	[47.9 ± 3.0]	[***17.1 ± 1.3***]	[17.5 ± 0.76]
Abies balsamea	9.0 ± 0.093	4.8 ± 0.086	5.6 ± 0.072	3.8 ± 0.053	9.0 ± 0.089	6.6 ± 0.037
	(***18.9 ± 1.2***)	(**6.9 ± 1.9**)	(***13.5 ± 1.5***)	(***8.4 ± 1.7***)	(***24.9 ± 1.6***)	(17.6 ± 0.75)
	[**10.2 ± 0.60**]	[7.3 ± 1.2]	[**7.8 ± 1.0**]	[**5.6 ± 0.77**]	[**11.1 ± 0.67**]	[**8.9 ± 0.33**]
Tsuga canadensis	0.12 ± 0.012	0	0	0	0	0.023 ± 0.0023
	(0.32 ± 0.16)	(0)	(0)	(0.81 ± 0.54)	(0.42 ± 0.25)	(**0.40 ± 0.14**)
	[0]	[0]	[0]	[0]	[0]	[0]
Larix laricina	0.082 ± 0.0097	8.5 ± 0.11	5.4 ± 0.075	6.0 ± 0.075	12.8 ± 0.16	7.1 ± 0.052
	(**0.48 ± 0.18**)	(**9.0 ± 2.1**)	(**7.3 ± 1.7**)	(3.7 ± 0.84)	(***3.8 ± 0.69***)	(2.6 ± 0.31)
	[1.5 ± 0.35]	[**9.5 ± 1.5**]	[**7.8 ± 1.2**]	[**8.8 ± 1.6**]	[**7.6 ± 0.81**]	[**5.3 ± 0.37**]
Thuja occidentalis	0	0	1.2 ± 0.037	0	0	0.20 ± 0.0064
	(0.42 ± 0.25)	(0.12 ± 0.13)	(***7.1 ± 1.7***)	(0)	(0.64 ± 0.32)	(0.93 ± 0.23)
	[0.023 ± –]	[0]	[0.38 ± –]	[0.15 ± –]	[0.39 ± 0.14]	[**0.17 ± 0.041**]
TOTAL CONIFERS	14.9	87.3	34.9	80.4	46.3	51.4
	(***30.4***)	(**94.4**)	(50.0)	(**84.1**)	(64.5)	(**47.3**)
	[23.8]	[**84.7**]	[**42.0**]	[**69.6**]	[**52.4**]	[**44.4**]
BROAD-LEAVES:						
Acer rubrum	35.7 ± 0.11	4.8 ± 0.086	25.7 ± 0.13	5.4 ± 0.061	20.1 ± 0.12	18.7 ± 0.063
	(**33.3 ± 1.4**)	(**2.5 ± 0.77**)	(**24.6 ± 2.4**)	(**4.6 ± 1.1**)	(**19.0 ± 1.5**)	(25.1 ± 1.2)
	[**30.4 ± 0.73**]	[**5.1 ± 1.1**]	[**26.3 ± 1.5**]	[**8.3 ± 1.1**]	[**18.9 ± 0.92**]	[**21.7 ± 0.52**]
Acer saccharum	21.6 ± 0.10	0	0.45 ± 0.030	0	0	4.3 ± 0.036
	(***9.7 ± 0.89***)	(0)	(1.7 ± 0.56)	(0.59 ± 0.46)	(0.28 ± 0.13)	(**4.9 ± 0.54**)
	[16.7 ± 0.76]	[0.5 ± –]	[2.1 ± 0.55]	[2.1 ± 0.60]	[3.5 ± 0.53]	[7.7 ± 0.38]
Betula alleghaniensis	7.8 ± 0.070	0	0.22 ± 0.016	0.013 ± 0.0026	0.090 ± 0.0024	1.6 ± 0.017
	(**5.6 ± 0.62**)	(0)	(3.3 ± 0.84)	(0.22 ± 0.13)	(1.4 ± 0.40)	(3.9 ± 0.39)
	[**6.7 ± 0.41**]	[0]	[0.71 ± 0.22]	[1.0 ± 0.35]	[0.92 ± 0.23]	[3.0 ± 0.19]
Betula papyrifera	13.7 ± 0.087	2.5 ± 0.059	12.7 ± 0.089	6.3 ± 0.059	13.4 ± 0.088	10.3 ± 0.039
	(9.2 ± 0.74)	(0.63 ± 0.36)	(***5.6 ± 0.94***)	(3.6 ± 0.78)	(***4.1 ± 0.60***)	(7.3 ± 0.50)
	[**13.1 ± 0.53**]	[**2.5 ± 0.65**]	[**11.9 ± 0.97**]	[**6.9 ± 0.85**]	[**11.4 ± 0.66**]	[**10.8 ± 0.33**]
Fagus grandifolia	1.5 ± 0.036	0	0.017 ± 0.0044	0	0	0.30 ± 0.0073
	(4.1 ± 0.58)	(0)	(0)	(0.37 ± 0.24)	(0.23 ± 0.11)	(2.7 ± 0.37)
	[**1.1 ± 0.19**]	[0]	[0.19 ± –]	[0.074 ± –]	[0.21± 0.10]	[**0.49 ± 0.074**]

(continued) on next page

TABLE 3. *(continued from previous page)*

	STAND-TYPES					
	Upland Hardwood Forest	Black Spruce Forest	Wet Rich Woodland	White Spruce Woods	"Disturbed Forest"	**ALL STANDS (All 1200 plots †) [All 1200 sampling point stands]**
Populus spp. ‡	4.6 ± 0.075 **(4.1 ± 0.65)** **[6.9 ± 0.53]**	5.0 ± 0.090 ***(1.1 ± 1.0)*** **[6.8 ± 1.2]**	21.4 ± 0.15 ***(7.8 ± 1.6)*** [11.2 ± 1.0]	7.6 ± 0.070 (4.7 ± 1.2) **[10.7 ± 1.1]**	18.8 ± 0.14 ***(7.4 ± 1.1)*** [10.9 ± 0.80]	12.3 ± 0.057 (6.6 ± 0.62) [9.6 ± 0.39]
Fraxinus americana	0 (0.40 ± 0.21) [0]	0 (0) [0]	0.32 ± 0.019 (1.6 ± 0.75) [0]	0 (0) [0]	0 (0) [0]	0.053 ± 0.0031 **(0.46 ± 0.16)** [0]
Ulmus americana	0 (0.26 ± 0.14) [0.47± –]	0 (0) [0]	0.84 ± 0.035 (3.2 ± 1.1) [0.13 ± –]	0 (0) [0]	0 (0) [0.035 ± –]	0.14 ± 0.0058 (0.57 ± 0.17) [0.042 ± 0.019]
Alnus incana	0.047 ± 0.011 (-) [0.16 ± 0.12]	0.26 ± 0.027 (-) [0]	4.8 ± 0.11 (-) **[4.0 ± 1.2]**	1.2 ± 0.039 (-) **[1.1 ± 0.63]**	1.9 ± 0.052 (-) [0.85 ± 0.38]	6.4 ± 0.071 (-) [1.1 ± 0.22]
TOTAL BROAD-LEAVES (excluding *Alnus*)	85.1 **(70.0)** **[75.6]**	12.5 ***(5.3)*** **[14.9]**	65.1 (50.0) **[56.7]**	19.6 **(16.5)** [30.3]	53.7 (35.0) [46.9]	47.8 **(52.7)** **[55.6]**
Number of Stands	16,170	8,049	13,863	22,709	22,166	82,957

† For "all 1200 plots" the value in round brackets is the percentage contribution to the total above ground biomass (oven-dry tonnes per hectare) in all 1200 variable-radius plots.

‡ Because it is impossible to distinguish the three native poplar species in aerial photographs (*Populus tremuloides*, *P. balsamifera*, *P. grandidentata*) they were grouped as "*Populus* spp." – however almost all of this is likely to have been *P. tremuloides* (Trembling Aspen).

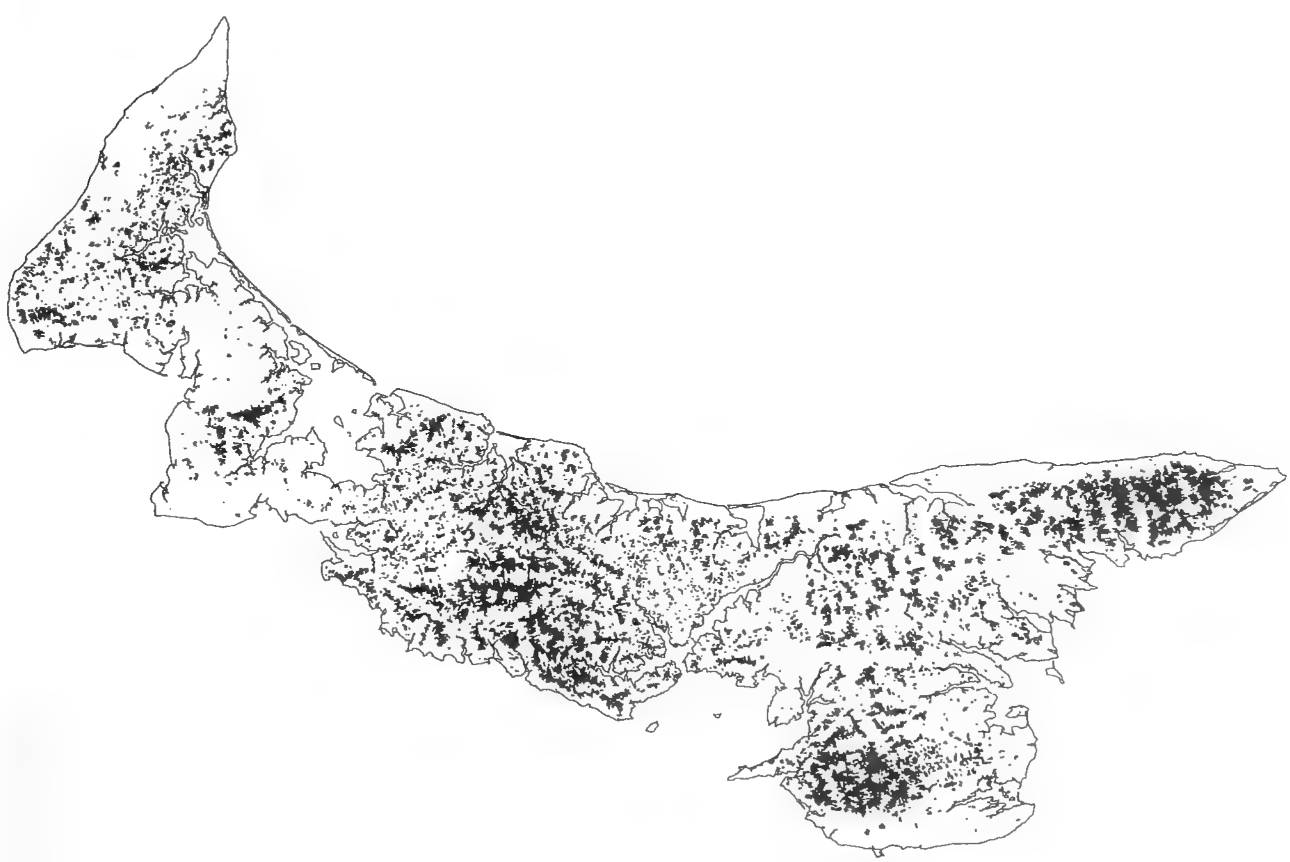

FIGURE 3. The distribution of stands of upland hardwood forest in 1990.

FIGURE 4. The distribution of stands of Black Spruce forest in 1990.

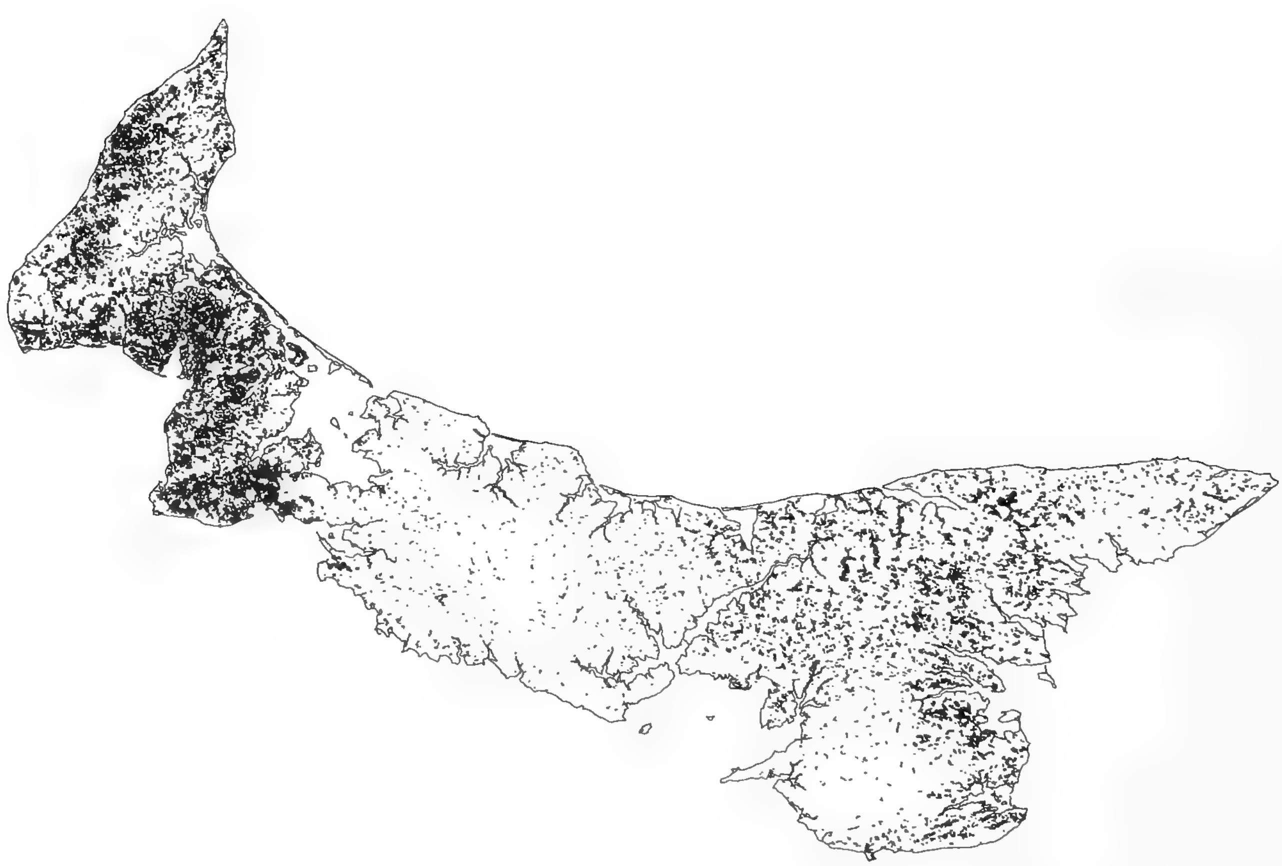

FIGURE 5. The distribution of stands of wet rich woodland in 1990.

FIGURE 6. The distribution of stands of White Spruce woods in 1990.

FIGURE 7. The distribution of stands of "disturbed forest" in 1990.

TABLE 4. The soil drainage classes of the stand-types (derived from the 1:10 000 soil series maps of MacDougall et al. (1988)) expressed as the percentage of the stand-type's total area in each drainage class, ignoring the area of unclassified drainage. These are compared with the drainage classes of the corresponding TWINSPAN forest-types: (1) (in round brackets) the soil drainage class at the sampling points of the 1991 field survey as determined from soil pits, and (2) [in square brackets] the drainage class of those soil series polygons in which the sampling points were located, derived also from MacDougall et al. (1988), both values being expressed as the percentage of the total area or of the sampling points in each drainage class. *

	STAND-TYPES					
SOIL DRAINAGE CLASS	Upland Hardwood Forest	Black Spruce Forest	Wet Rich Woodland	White Spruce Woods	"Disturbed Forest"	**ALL STANDS** (or points)
Poorly- and imperfectly-drained soils (+ organic)(%)	9.8	79.4	95.7	20.6	23.6	39.2
	(***1.9***)	(**66.3**)	(58.3)	(***1.5***)	(15.9)	(***18.4***)
	[**12.9**]	[**73.8**]	[**80.3**]	[14.0]	[***37.5***]	[**33.6**]
Well- and rapidly-drained soils (%)	90.2	20.6	4.3	79.4	76.4	60.8
	(**98.1**)	(***33.8***)	(***41.6***)	(98.5)	(**84.1**)	(81.6)
	[**87.1**]	[26.3]	[***19.9***]	[**85.9**]	[**62.5**]	[**66.4**]

*For the meaning of the bolding and italicizing see the caption of Table 3.

and the 1990 aerial stand database, and then linked to the "MapInfo" G.I.S. for the province.

(1) Comparing the composition of the tree canopy

To facilitate the overall interpretation of the many comparisons being made, indices were selected for assessing the closeness of the two values: if the equivalent parameter for the TWINSPAN-based forest-type lay within ± 20% of the aerial-stand value, this was taken to indicate "good agreement" between the two values, whereas if the parameter was greater than ± 50% of the aerial-stand value this was considered a "notable discrepancy". On the basis of these criteria, it is evident that in overall terms there is a reasonably good fit between the mean tree canopy composition of the stand-types based on all of the stand polygons (Table 3), and the canopy composition of those stand polygons that contained the 1200 variable-radius plots: there are 29 "good agreements" and only two "notable discrepancies" for the crown closure of individual species. However, when the mean tree canopy composition for all of the stand polygons is compared with the percentage contribution to woody biomass in the variable-radius plots, the match is not as good: here there were 15 "good agreements" and 17 "notable discrepancies". This greater level of discrepancy is not surprising considering that this latter comparison is between plots of different size (i.e., forest stands of variable size, but measured mostly in hectares (the mean stand area was about 3 hectares) and variable-radius plots with a mean size of about 100 m^2), as well as different parameters (percentage crown closure as determined from an aerial photograph, with the percentage contribution to woody biomass based on the trunk diameter of the trees within the variable-radius plots).

Also relevant here is the greater difficulty in identifying tree species from an aerial photograph compared with the examination of actual specimens in a field survey. The photo-identification was based on such characters as texture, shape, colour and site (e.g., whether on upland or lowland). The conifers in particular presented problems: Balsam Fir (*Abies balsamea*) when present as an understorey species may not be apparent from the air; the three spruce species were frequently identified from their site: i.e., if in upland forest, it was listed as Red Spruce (*Picea rubens*), in lowland, Black Spruce, and on old-field sites, White Spruce, but this was not an infallible approach. Thus the photo-identification was not 100% accurate: the standard required for the 1990 aerial survey, confirmed by ground checks, was that at least 70% of the species-cover identification in a stand be correct for at least 90% of the time. Bearing these points in mind we observe the following:

Upland hardwood stands. In almost all of the comparisons (Table 3) there is generally a good correspondence between the parameters of the aerial stand-type and those of the TWINSPAN-defined forest-type.

Black Spruce stands. There are problems with the spruces (perhaps due to the problem in identifying the spruces, discussed above): in Table 3 the most notable discrepancy is the very low Red Spruce contribution to the aerial stand-type (<1%) compared with its level in the variable-radius plots (17%). Also evident is the fact that Black Spruce is at a somewhat higher level in the aerial stand-type (71%) compared with either of the values for the TWINSPAN-defined forest-type. This is presumably due to the high crown closure level (i.e., 50%) that was set as the criterion for inclusion of Black Spruce stands in this group.

Wet rich woodland stands. The chief species, Red Maple, shows no difference in either of the comparisons

(Tables 3). However, there are some discrepancies: the use of a sorting criterion of ≥ 50% hardwoods must be the reason for the higher overall hardwood contribution in the aerial stand-type compared with the TWINSPAN forest-type, as well as the higher individual contributions of Trembling Aspen (*Populus tremuloides*) and White Birch (*Betula papyrifera*), though there is no discrepancy for the latter species in the comparison of the crown closures. Concomitantly, the conifer contribution is less in the aerial stand-type than in the variable-radius plots, but again there is less discrepancy for the crown closure comparison.

White Spruce stands. In overall terms there is a good correspondence between the two classifications, with the main species, White Spruce, giving a reasonably good fit – this time the better fit is for the variable-radius plot comparison (Table 3).

"Disturbed forest" stands. This residual group has a smaller total conifer component than the TWINSPAN "disturbed conifer-dominated forest" (this discrepancy is less evident in the comparison of the crown closures – Table 3), and this is reflected especially in the levels of Balsam Fir (for the variable-radius plot comparison only), and to a smaller degree, in White Spruce and Black Spruce. Oddly, Tamarack (*Larix laricina*) is considerably higher in the aerial stand-type than it is in the variable-radius plots. Concomitantly, the hardwoods (notably Trembling Aspen) are higher in the aerial stand-type, while there is no difference for the levels of Red Maple.

(2) Comparing the soil drainage classes and the 1935 status

There is a reasonably good agreement between the aerial stand-types and the TWINSPAN forest-types in their drainage class breakdown (Table 4), especially for the drainage classes as determined from the soil series at the 1200 sampling points. There is less agreement with the drainage classes as determined from the soil pits dug at the sampling points during the field inventory. The one showing the least correspondence is the wet rich woodland which has higher levels of poorly- and imperfectly-drained soils in the aerial stands, due to the direct use of these drainage classes as a sorting criterion. The status of the stands and sampling points in 1935 (i.e., whether they were forested or cleared land at that time) is in broad agreement for most of the forest-types (Table 2), with the greatest discrepancy being for the White Spruce woods.

Discussion

The TWINSPAN analysis of the 1991 field survey data (Sobey and Glen 2002) indicated the presence of five main forest-types on Prince Edward Island, three of these showing a relationship with pre-European settlement forest-types and two appearing to largely owe their presence to human influences. The objective of the current paper was the production of maps showing the total distribution of these five forest-types. This objective has been achieved, and for the first time ever we have fine-scale whole-island maps showing the distribution of the main forest-types. Furthermore, these maps have been produced using largely objective criteria and methods, and they are based on the actual forest present at a specific time (in the summer of 1990), with every mapped stand being locatable on the ground and thus potentially verifiable.

How valid are the maps as a picture of the distribution of the five forest-types on the island? Firstly, the maps appear to make ecological and geographical sense: the upland hardwood forest (Figure 3) occurs in areas of higher elevation (in island terms), and on soils having good drainage (Tables 2 and 4). In such areas the mapping indicates that it is present either as small woodlots surrounded by farmland, or as larger connected parcels (at the back end of farms) – especially in the central and south-eastern hill-lands, where steeper slopes and shallow soils placed restrictions on forest clearance in the past.

It is also evident that the Black Spruce forest and the wet rich woodland, which occur primarily on soils with poorer drainage (Tables 2 and 4), are segregated geographically from the upland hardwood forest. These predominate in areas of lower elevation, notably in parts of the east and west of the island (Figures 4 and 5). Though both of these forest-types occur in the same geographical areas, the TWINSPAN analysis indicated that they have very different ground and tree vegetation (Sobey and Glen 2002). They also have very different soil chemical properties – the wet rich woodland has soils that are comparatively base-rich and of higher pH with a lower C/N (carbon-nitrogen) ratio, than the soils of Black Spruce forest, more acid and base-poor with a higher C/N ratio. This dissimilarity was also evident from the fact that there was no overlap in their graphical distributions in the DECORANA ordination (Sobey and Glen 2002). Given their similar geographical distribution on the island, the question is whether in the mapping we have been able, using tree and soil criteria alone, to separate the stands of these two wet forest-types from each other. The differences in their tree composition parameters, evident in Table 3, suggest that we have.

Stands of the other two forest-types, the White Spruce woods and the disturbed forest, have a wider and more scattered distribution (Figures 6 and 7), occurring less as larger connected parcels, than as individual small stands, which is consistent with the fact that their occurrence is largely the product of human activity, which will tend to occur at a scale determined by the ownership of blocks of land. At the same time there is a geographical aspect to their distribution, with the White Spruce woods prevalent in the central hill-lands and in the eastern part of the island, its spatial distribution evidently determined by the geography of field and farm abandonment, while the disturbed forest is con-

TABLE 5. For each soil drainage class, the total area (in hectares) under the three 'primary' forest stand-types in 1990, and the percentage of this area assigned in the computer-sorting to each stand-type is shown.

	DRAINAGE CLASS					
PRIMARY FOREST STAND-TYPES	Organic	Poorly-drained	Imperfectly drained	Well-drained (medium textured)	Well-drained (coarse textured)	Rapidly-drained
Upland Hardwood Forest	0.88	6.2	12.0	68.7	91.2	64.4
Black Spruce Forest	86.5	35.6	30.7	16.7	6.7	30.6
Wet Rich Woodland	12.6	58.2	57.3	14.6	2.1	5.0
Total Hectares	2 620	50 912	18 089	2 137	44 865	11 073

centrated largely in the far west and in the east of the island.

Although a significant and meaningful ecological picture has emerged from the sorting and mapping, at the same time it is important to point out some limitations: a basic one is that any sorting of forest stands into forest-types is a classification procedure, and any process of classification is a simplification. Compounding this was the fact that the stand sorting was reliant on the products of three other classification procedures: TWINSPAN, stand delineation (strictly-speaking not a classification procedure, but involving demarcation of the forest area into individual stands), and the soil series classification for the province. Each of these three prior procedures will have their own particular limitations.

It should also be pointed out that although three centuries of forest destruction and exploitation by Europeans have undoubtedly generalized and simplified the island's forest cover, the five maps are still a simplification of what was present in 1990. As noted in Sobey and Glen (2002) there are likely to have been other forest-types present but so uncommon as not to have been picked up in the 1991 field survey in sufficient quantity to be recognized as separate types (e.g., areas under Hemlock, White Pine, Eastern White Cedar and White Ash, now occurring as only a few small stands, but likely to have been more widespread in the past). Also, each of the five forest-types that has been recognized may have had sub-types that have been overlooked: e.g., the TWINSPAN classification subdivided the Black Spruce forest plots into wetter and dryer variants (Sobey 1995), but an attempt in the sorting to separate stands of these on their tree canopy composition was not successful. The upland hardwood may also have variants dominated by particular tree species. The only solution to this problem of both rare and more refined forest-types, is firstly to define them, and then to locate them on the ground and map them separately.

It should also be noted that the maps produced present a picture of the forest as it was at one particular time: in the summer of 1990 at the time of the aerial photographic survey. But the forests of Prince Edward Island, like forests the world over, are not fixed and static. Apart from natural factors, they are subject to the effects of continual human interference, for example, clear- and partial-cutting, forest clearance for agriculture, fire, and farm abandonment, as well as the natural successional processes resulting from these effects. On the other hand, although the three pre-European settlement woodland types may vary over time in the amount and proportion of the island's area that they occupy, we should not expect the general pattern of their distributions to change, related as this is to innate soil properties. However, the two successional forest-types (White Spruce woods and disturbed forest) are likely to be only transitional on a site, and we may presume that given sufficient time, most of their sites would develop into one of the primary woodland types.

Mapping the pre-European settlement forest of the island

Despite the above limitations in the methodology, it is of interest to generalize the results even further by considering the potential for extending the mapping to areas without forest cover in 1990, incidentally, an aspect of all earlier attempts at mapping the province's forests (Stilgenbauer 1929; Halliday 1937; Rowe 1959; Loucks 1962). Such a mapping may have either of two objectives: (1) the reconstruction of the type of forest likely to have occurred before forest clearance, i.e., the "original-natural" forest *sensu* Peterken (1996); and/or (2) the prediction of the type of forest that would ultimately occur over the whole island if all areas were allowed to revert naturally to climax forest in the future; i.e., the "future-natural" forest *sensu* Peterken (1996). Either of these objectives involves trying to predict the climax forest-type on the land area now occupied by White Spruce woodland and the "disturbed forest", as well as the forest cover on land which in 1990 was clear of forest, i.e., the non-forested area evident in Figure 2, comprising some 43% of the island's land area (Anonymous 1992).

The easiest approach to such a mapping is to take advantage of the close relationship existing between natural vegetation and soils, by utilizing data derived from the comprehensive and fine-scale maps produced by the Prince Edward Island Soil Survey (MacDougall et al. 1988). We need first to examine any associations

FIGURE 8. The conjectured distribution of upland hardwood forest prior to European settlement – based on combining the distribution of upland hardwood stands in 1990 with that of well-drained soils as mapped by the Soil Survey of Prince Edward Island (MacDougall et al. 1988).

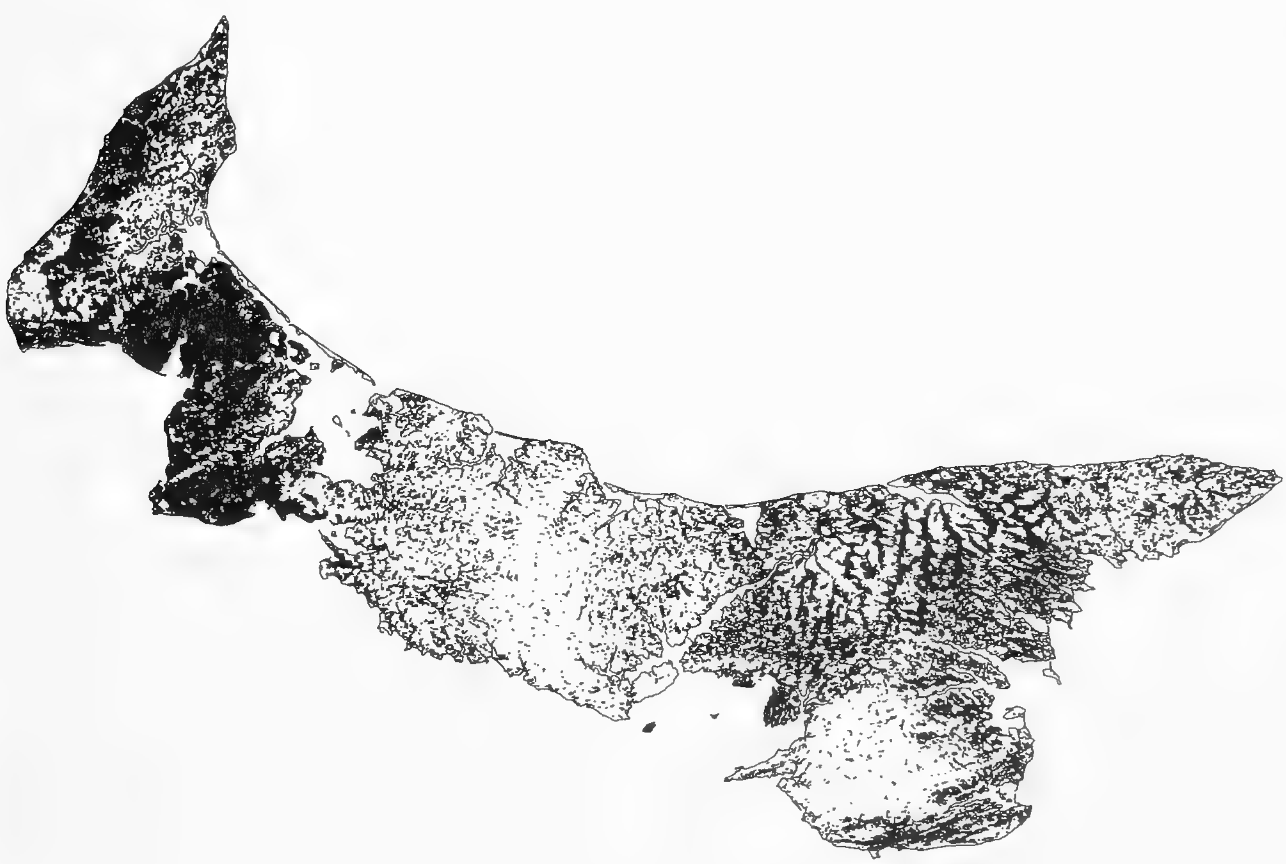

FIGURE 9. The conjectured distribution of wet rich woodland and Black Spruce forest prior to European settlement – based on combining the distribution of stands of these two forest-types in 1990 with the distribution of imperfectly- and poorly-drained soils (excluding stream complexes) as mapped by the Soil Survey of Prince Edward Island (MacDougall et al. 1988).

occurring between the three pre-settlement forest-types and the soils of different drainage properties: Table 5 shows for each drainage class the percentage of its "primary forest" component contributed by each of the three primary forest-types.

From Table 5 it is evident that well-drained coarse-textured soils (and to a less extent well-drained medium-textured soils) have a strong association with upland hardwood forest (some 91% of the well-drained coarse soils and 69% of the medium soils have such a forest cover). By contrast, poorly and imperfectly drained soils are strongly associated with the two other pre-settlement forest types (wet rich woodland and Black Spruce forest) – some 94% of poorly-drained and 88% of imperfectly-drained sites carry such forests. However, although these two "wet" forest-types (as noted in Sobey and Glen (2002) and above), occupy soils of markedly differing chemical properties (in terms of pH, base status and C/N ratios), such chemical properties were not criteria used to characterize the soil series in the 1988 Soil Survey, and thus the soil series maps cannot be used to differentiate these two forest-types. Then there is the problem presented by the remaining soil drainage class, rapidly-drained soils (Table 5): 64% of such soils carry upland hardwood forest, but a significant proportion (30%) has a cover of Black Spruce forest, more likely the dryer variant of the Black Spruce forest, shown in the TWINSPAN analysis (Sobey 1995) to have some association with rapidly-drained soils.

On the basis of the above relationships, Figure 8 is an attempt to show the approximate distribution of the pre-settlement upland hardwood forest, and presumably also the area that is capable of reverting to such forest in future. The map has been constructed by taking the 1990 distribution of upland hardwood forest (Figure 3) and adding to it the area occupied by well-drained soils (both coarse and medium-textured parent materials). It is likely that additional areas under rapidly-drained soils, particularly in the south-eastern hill-lands, would also have carried some form of upland hardwood forest, but given the present state of our information, it is not possible at this stage to distinguish the hardwood-bearing areas of such soils from the Black Spruce areas.

Figure 9 is an attempt to show the area occupied before European settlement by the two wet forest-types (the wet rich woodland and the Black Spruce forest). It has been constructed by adding to the 1990 distribution of these forest-types (i.e., Figures 4 and 5), the combined distribution of poorly- and imperfectly-drained soils. Given the present state of the information incorporated within the G.I.S. database for the province, this is about as far as we can go for wet woodland. Distinguishing between these two woodland types would require data on the chemical properties of the soils. And, as noted above, Table 5 indicates that Black Spruce forest (presumably the dryer variant) will have also occurred on land having rapidly-drained soils. It is also likely that it is on such soils that the now largely extirpated pine forests of the island would have occurred in the past.

The picture that emerges from these maps is of an island that was mostly covered by upland hardwood forest, which formed a large continuous block in the central part of the island, with smaller but significant blocks in the western and eastern parts. By contrast, the wetter forest-types occurred at lower elevations in specific areas in the west and in a more scattered mosaic pattern in the east. It is thus on these lowland sites that the boreal element of the island's forests, in the form of Black Spruce forest, had a greater occurrence. Such a division of the landscape, based on soil moisture levels, between the northern hardwood forest and the boreal forest, appears to be typical in the boreal-broadleaf ecotone (Pastor and Mladenoff 1992; Scott 1995).

It should be noted that compared with earlier attempts at mapping the pre-settlement forest (e.g., Stilgenbauer 1929; Loucks 1962) the maps presented here have a much finer scale of detail in their boundary lines. Also, the validity of the maps, as showing the forest distribution before European settlement, can be tested by comparing them with early historical descriptions of the forest, especially from the data contained in early maps and surveyors' field notebooks in the provincial archives. Not only would such a comparison allow us to ascertain the forest-types that actually occurred on many sites before forest clearance, it may also provide data on the fine-scale differences in the forests of such sites, in some cases even as to particular tree species. However this is beyond the scope of the present study. By contrast, the validity of the maps as pictures of the "future-natural" forest will only be testable from what happens if such areas revert to forest in future.

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APPENDIX 1. Summary descriptions of the five forest stand-types arising from the computer-sorting of 82 957 forest stands.

UPLAND HARDWOOD FOREST 16 170 stands (19.5%); 55 043 ha (21.7%)

A stand-type of widespread occurrence on well-drained soils (77% of its area is on such soils – plus an additional 13% on rapidly-drained soils), especially away from the coast and further back from roads, in the central and south-eastern hill-lands, in the north-east peninsula, and in smaller specific areas in the east and west of the island. 94% of its area had a forest cover in 1935. The tree canopy is dominated by hardwoods (accounting for 85% of crown closure) – particularly Red Maple (36%), with a notable contribution by Sugar Maple (22%), and smaller amounts of Yellow Birch (8%) and American Beech (2%). There is also a significant component of White Birch (14%) and Trembling Aspen (5%). The minority conifer component (15%) consists largely of Balsam Fir (9%), with some White Spruce (5%). The high contribution to crown closure by Red Maple, and the presence of White Birch and Trembling Aspen, are indicative of a high level of past, and we may presume, continuing, human disturbance. This stand-type is the direct descendant of the pre-European settlement upland hardwood forest postulated by Erskine (1960), though subject to varying levels of past and current human disturbance.

BLACK SPRUCE FOREST 8 049 stands (9.7%); 33 106 ha (13.1%)

A rather localized stand-type occurring primarily on areas with poor and imperfect drainage – 78% of its area is on such soils – especially in specific parts of the west and east of the island. The tree canopy is dominated by conifers (comprising 87% of crown closure), above all Black Spruce (71%) – with small contributions by Tamarack (9%) and Balsam Fir (5%). The 13% contributed by hardwoods comes largely from Red Maple (5%) and Trembling Aspen (5%). Most of the area (77%) had a forest cover in 1935. This stand-type corresponds to the pre-settlement lowland Black Spruce forest of Erskine (1960).

WET RICH WOODLAND 13 863 stands (16.7%); 42 192 ha (16.6%)

A stand-type almost completely confined to areas of poorly- and imperfectly-drained soils (95% by ground area) especially in the west of the island, as well as parts of the east. The tree canopy is dominated by hardwoods (making up 65% of crown closure), but there is also a notable conifer contribution (35%). The chief hardwood species are Red Maple (26%), Trembling Aspen (21%) and White Birch (13%). (White Cedar, American Elm and White Ash are present at low levels). The main conifers are Black Spruce (10%), White Spruce (8%), Balsam Fir (6%) and Tamarack (5%). 76% of its area was under forest cover in 1935. This stand-type appears to be a derivative of the pre-settlement lowland Red Maple forest of Erskine (1960) – though with considerable effects due to cutting and other disturbances.

WHITE SPRUCE WOODS 22 709 stands (27.4%); 57 982 ha (22.9%)

A widely scattered stand-type occurring as small often field-shaped parcels on well- and rapidly- drained soils (78% by area is on such soils). It is prevalent in the central hill-lands and even more towards the east of the island. A high proportion of its area (62%) was cleared land in 1935. The tree canopy is dominated by a single species, White Spruce, at a high level of crown closure (68%). The remaining species contribute only small amounts: Trembling Aspen (8%), White Birch (6%), Tamarack (6%), Red Maple (5%) and Balsam Fir (4%). This stand-type corresponds to the successional "old field" White Spruce woods of Erskine (1960).

"Disturbed Forest" 22 166 stands (26.7%); 65 259 ha (25.7%)

This residual stand-type (i.e., that left over after the stands of the other four types had been selected) is widely scattered, generally as small individual parcels (rather than large blocks), especially in the east and west of the island, notably on well- and rapidly-drained soils (75% by area occurred on such soils). The tree canopy has a slight predominance of hardwoods (54%) – the principal species being Red Maple (20%), Trembling Aspen (19%) and White Birch (13%). Its large conifer component (46%) is made up of Tamarack (13%), White Spruce (10%), Balsam Fir (9%), Red Spruce (7%) and Black Spruce (5%). 33% of its area was cleared land in 1935. This stand-type does not equate with any of Erskine's pre-European forest-types – its species make-up and distribution suggest rather that it is largely a successional community heavily affected by past and continuing human exploitation.

Inventaire printanier d'une frayère multispécifique : l'ichtyofaune des rapides de la rivière Gatineau, Québec

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Un inventaire ichtyologique printanier a été réalisé dans la rivière Gatineau, dans le premier rapide à l'amont de son embouchure dans la rivière des Outaouais, pour établir la chronoséquence d'utilisation du site par les espèces s'y reproduisant, dont trois espèces de chevaliers. L'échantillonnage des rapides a permis de capturer 2388 poissons répartis en 13 familles et 39 espèces, dont six ayant fait l'objet d'une évaluation par le COSEPAC. Seize espèces étaient en état de se reproduire lors de l'échantillonnage. Nous avons observé une reproduction plus ou moins simultanée pour le Chevalier blanc et le Chevalier rouge, suivie de celle du Chevalier de rivière. Également, pour ces trois espèces, nous avons observé la capture des mâles de stade V plus tôt que les femelles, et nous les retrouvons en plus grand nombre. Ceci pourrait s'expliquer du fait que les mâles précèdent les femelles sur les frayères, que celles-ci sont reconnues pour rester très peu de temps sur les sites de fraie et qu'un minimum de deux mâles par femelle est requis pour la reproduction. Cette étude démontre que les rapides de la rivière Gatineau doivent être protégés puisqu'ils sont habités par trois espèces qui ont obtenu un statut spécial du COSEPAC (Menacée: Fouille-roche gris; situation préoccupante : Lamproie du nord et Chevalier de rivière) en plus de constituer une frayère multispécifique importante.

Mots-clés: Rapides, Rivière Gatineau, Outaouais, Fraie, Chevalier blanc, *Moxostoma anisurum, Chevalier de rivière, Moxostoma carinatum,* Chevalier rouge, *Moxostoma macrolepidotum,* Lamproie du nord, *Ichthyomyzon fossor,* Fouille–roche gris, *Percina copelandi.*

A spring survey of fishes was conducted in the Gatineau River (Quebec), in the first rapids upstream of its confluence with the Ottawa River, to establish the fish spawning chronosequence, especially for the three species of redhorses. The sampling resulted in the capture of 2388 fish belonging to 13 families and 39 species. Six of these species have been assessed by COSEWIC. Sixteen species were in spawning readiness. Spawning of the Silver Redhorse and Shorthead Redhorse occurred first, followed by the River Redhorse. Stage V males of the three redhorse species were captured earlier and in greater numbers than females. These observations are consistent with other studies which suggest that males precede females to the spawning grounds, that females remain there for a short period and that a minimum two males per female is required for reproduction. This study shows that the Gatineau River rapids must be protected because they harbor three species that have obtained a status by COSEWIC (Threatened: Channel Darter; Special concern: Northern Brook Lamprey and River Redhorse) as well as being an important multi-species spawning ground.

Key Words: Rapids, Gatineau River, Outaouais, spawning, Silver Redhorse, *Moxostoma anisurum*, River Redhorse, *Moxostoma carinatum*, Shorthead Redhorse, *Moxostoma macrolepidotum,* Northern Brook Lamprey, *Ichthyomyzon fossor,* Channel Darter, *Percina copelandi.*

Un inventaire réalisé au printemps 1989 à l'aide de filets de dérive a permis de constater que les rapides de la rivière Gatineau en aval du barrage hydroélectrique de Farmer's Point (Gatineau, Québec) (Figure 1) sont utilisés pour la reproduction de l'Esturgeon jaune, des Percidae (*Sander* spp. et *Perca flavescens*), et des Catostomidae (*Catostomus* spp. et *Moxostoma* spp.) (Houde et Fournier 1992). Une pêche expérimentale réalisée en 1998 (données non publiées) a révélé la présence à ce site d'une concentration exceptionnelle de Chevalier de rivière. Des travaux furent donc entrepris en 1999 pour décrire cette population et son utilisation du rapide Farmer's.

L'étude ichtyologique de ce secteur de la rivière revêt un intérêt particulier parce que le barrage agit comme barrière au déplacement des poissons vers l'amont. Ceci pourrait occasionner une concentration de poissons dans le secteur des rapides en aval du barrage, en particulier au printemps, lors des migrations reproductrices. Ainsi, le secteur en aval du barrage pourrait être un site privilégié pour la reproduction des poissons provenant des rivières Gatineau et des Outaouais.

Le but de notre étude est de présenter l'inventaire printanier des espèces de poissons de ce secteur de la rivière alors que plusieurs de celles-ci sont normalement en période de fraie. De plus, une attention particu-

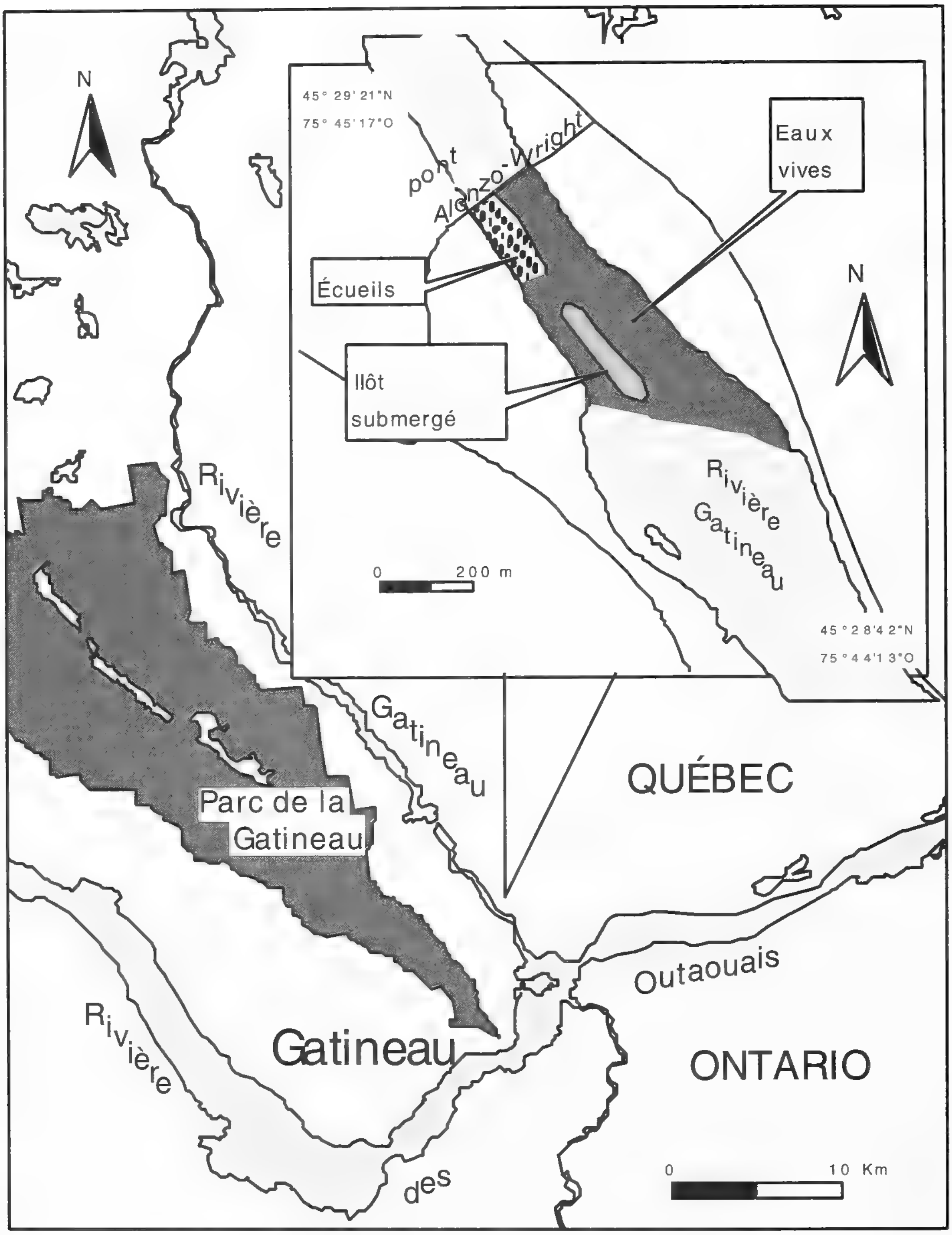

Figure 1. Site de la rivière Gatineau près du pont Alonzo-Wright, se trouvant à 5,2 km de la jonction avec la rivière des Outaouais.

lière sera portée sur la répartition dans le temps de la reproduction des trois espèces de chevalier (*Moxostoma* spp.) qui utilisent le secteur des rapides pour frayer.

Site d'échantillonnage

La section de la rivière Gatineau (45°29'N, 75°44'O) échantillonnée se trouve entre 6,0 et 5,2 km de l'embouchure sur la rivière des Outaouais (Figure 1). La zone d'échantillonnage couvre une longueur de 800 m et est délimitée en amont par le pont Alonzo-Wright et à l'aval par l'extrémité d'une île localisée près de la rive ouest de la rivière. La largeur de la rivière dans ce secteur varie de 170 m en amont à 330 m en aval et couvre une superficie d'environ 22 ha. La profondeur de l'eau varie de 0,5 à 5 m. Le courant est particulièrement rapide sur une distance d'environ 400 m à l'aval du pont et la vitesse devient beaucoup plus lente par la suite alors que la rivière s'élargit et devient plus profonde.

Dans les eaux rapides, le substrat est composé de galets, de cailloux et de gros blocs épars dans le centre de la rivière et de gravier en rive ouest. La rive est a été largement modifiée par des remblayages et la construction de quais et murs de soutènement. En aval, où la rivière est plus large et le courant plus lent, le fond est constitué de gravier, de cailloux et de galets; en rive ouest, le substrat est composé de sable

TABLEAU 1. Espèces recensées lors de l'échantillonnage du rapide Farmer's, rivière Gatineau, au printemps 1999.

Famille	Nom latin (Espèce)	Nom commun français	Nombre d'individus
Petromyzontidae	*Ichthyomyzon unicuspis*	Lamproie argentée	8
	Ichthyomyzon fossor	Lamproie du nord	1
	Lampetra appendix	Lamproie de l'est	31
Acipenseridae	*Acipenser fulvescens*	Esturgeon jaune	19
Hiodontidae	*Hiodon tergisus*	Laquaiche argentée	276
Anguillidae	*Anguilla rostrata*	Anguille d'Amérique	1
Cyprinidae	*Luxilus cornutus*	Méné à nageoires rouges	4
	Notemigonus crysoleucas	Méné jaune	2
	Notropis atherinoides	Méné émeraude	309
	Notropis hudsonius	Queue à tache noire	2
	Rhinichthys cataractae	Naseux des rapides	1
	Semotilus corporalis	Ouitouche	52
Catostomidae	*Carpiodes cyprinus*	Couette	68
	Catostomus commersoni	Meunier noir	33
	Moxostoma anisurum	Chevalier blanc	223
	Moxostoma carinatum	Chevalier de rivière	270
	Moxostoma macrolepidotum	Chevalier rouge	254
Ictaluridae	*Ameiurus nebulosus*	Barbotte brune	9
	Ictalurus punctatus	Barbue de rivière	57
	Noturus insignis	Chat-fou liséré	3
Esocidae	*Esox lucius*	Grand brochet	1
	Esox masquinongy	Maskinongé	4
Salmonidae	*Salmo trutta*	Truite brune	1
	Salvelinus namaycush	Touladi	1
Percopsidae	*Percopsis omiscomaycus*	Omisco	5
Centrarchidae	*Ambloplites rupestris*	Crapet de roche	116
	Lepomis gibbosus	Crapet-soleil	9
	Lepomis macrochirus	Crapet arlequin	4
	Micropterus dolomieu	Achigan à petite bouche	17
	Micropterus salmoides	Achigan à grande bouche	1
	Pomoxis nigromaculatus	Marigane noire	22
Percidae	*Etheostoma nigrum*	Raseux-de-terre noir	1
	Etheostoma olmstedi	Raseux-de-terre gris	12
	Perca flavescens	Perchaude	79
	Percina caprodes	Fouille-roche zébré	315
	Percina copelandi	Fouille-roche gris	76
	Sander canadensis	Doré noir	16
	Sander vitreus	Doré jaune	80
Sciaenidae	*Aplodinotus grunniens*	Malachigan	5

et de limon alors que la rive est a aussi été largement modifiée par les activités humaines.

Méthodes

L'échantillonnage s'est effectué à intervalle de 1 à 5 jours, du 29 avril au 23 juin 1999, entre 19:00 h et 01:00 h. Il s'est fait à l'aide d'un bateau de pêche électrique de marque Smith Root 16R. Des voltages de 250 à 1000 V et des ampérages de 0,25 à 3,00 A ont été utilisés selon la conductivité de l'eau. La pêche débutait à 20 m des piliers du pont Alonzo-Wright. Une dérive contrôlée du bateau était faite sur des transects de 400 à 800 m le long des rives et au centre de la rivière. La période de pêche active (lorsque le courant était émis dans l'eau) variait de 320 à 1732 s. Les poissons capturés étaient déposés dans un vivier installé sur le pont du bateau. Une fois le vivier rempli, la pêche active était arrêtée et les poissons étaient examinés et relâchés, sauf pour quelques spécimens qui ont été conservés pour des études ultérieures.

Les poissons étaient identifiés, dénombrés et le sexe ainsi que le stade de reproduction étaient déterminés lorsque cela était possible. Pour les chevaliers, le sexe était établi à partir de la présence de tubercules nuptiaux (Scott et Crossman 1974). Le stade de reproduction était déterminé par des caractéristiques morphologiques externes et selon l'index de maturité des gonades de Nikolsky (1963). Celui-ci classe les stades en six catégories. Les stades I, II et III, ne sont pas identifiables puisqu'ils reflètent des états de maturation des gonades qui ne montrent pas de signes externes. Le stade IV est caractérisé par l'identification de gonades fermes et gonflées au toucher de la paroi abdominale sans expulsion d'œufs ou de sperme. Le stade V est identifié lorsqu'il y a expulsion de produits sexuels par simple pression de l'abdomen.

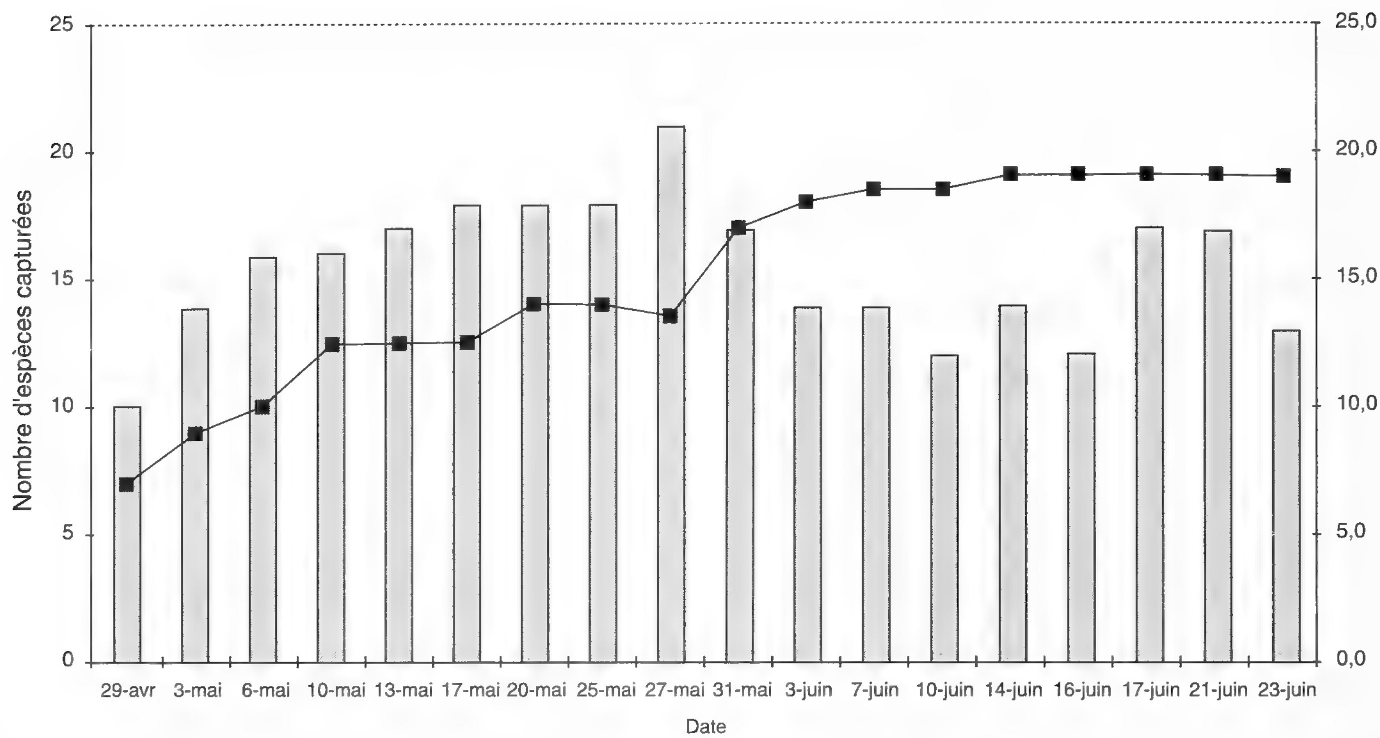

FIGURE 2. Évolution temporelle du nombre d'espèces capturées et de la température de l'eau (■) au rapide Farmer's, printemps 1999.

Un poisson au stade VI a un abdomen relativement flasque et sans expulsion massive de produits sexuels par pression abdominale.

L'échantillonnage ciblant surtout les chevaliers, l'abondance des espèces de petite taille est probablement une sous-estimation de leur présence dans le milieu.

Résultats

Familles et espèces capturées

L'échantillonnage des rapides de la rivière Gatineau a permis de capturer 2388 poissons en 12 heures de pêche active réparties sur 18 jours entre le 29 avril et le 23 juin 1999. Les captures se répartissent en 13 familles et 39 espèces (Tableau 1). Les Percidae dominent pour le nombre d'espèces capturées (sept espèces). Les Cyprinidae et les Centrarchidae sont représentés par six espèces chacune. Les Catostomidae dominent pour le nombre de spécimens (848), les chevaliers constituant 88% des captures. Un seul spécimen des Anguillidae (*Anguilla rostrata*) a été capturé (Tableau 1). D'ailleurs, un seul spécimen a été capturé pour huit espèces (Tableau 1) alors que plus de 300 spécimens ont été capturés pour le Méné émeraude (309) et le Fouille-roche zébré (315).

Six des espèces capturées ont fait l'objet d'une évaluation par le Comité sur la situation des espèces en péril au Canada (COSEPAC 2003) : l'Esturgeon jaune (non en péril; 1986), le Chevalier de rivière (situation préoccupante; 1987), le Chat-fou liséré (menacé; 1989 et données insuffisantes lors de la révision de 2002), la Lamproie du nord (situation préoccupante; 1991), le Fouille-roche gris (menacé; 1993, 2002) et le Raseux-de-terre gris (non en péril; 1993). Deux de ces espèces, le Chevalier de rivière et le Fouille-roche gris ont été capturés en grand nombre dans la rivière Gatineau, soit 270 et 76 individus respectivement (Tableau 1).

Comme nous pouvons le constater à la Figure 2, le plus petit nombre d'espèces capturées a été de dix lors de la première sortie, le 29 avril. Il a augmenté graduellement pour atteindre un maximum de 21 espèces le 27 mai. Par la suite, le nombre a diminué, variant de 12 à 17 espèces par sortie.

Reproduction

Des individus de 16 des espèces capturées étaient au stade V du cycle de reproduction et semblent donc y avoir frayé (Tableau 2). Pour plusieurs de ces espèces, nos captures permettent de délimiter une période de reproduction probable et les températures auxquelles elle se serait produite. Pour quelques espèces, des individus en état de fraie (stade V) étaient présents dès la première journée d'échantillonnage ou encore présents la dernière journée. Dans ces cas, il est possible que la période de reproduction s'étende au-delà de la période d'échantillonnage. Des individus des deux sexes de tous les stades avancés de développement des gonades (stades IV, V, VI) ont été observés pour cinq espèces seulement : le Chevalier blanc (*Moxostoma anisurum*), le Chevalier de rivière (*M. carinatum*), le Chevalier rouge (*M. macrolepidotum*), la Couette (*Carpiodes cyprinus*) et la Laquaiche argentée (*Hiodon tergisus*).

Reproduction des trois espèces de chevalier

L'abondance des captures permet d'établir la chronoséquence des périodes de reproduction des trois espèces de chevaliers dans la rivière Gatineau (Figures 3 et 4). Pour toutes les espèces, des spécimens de

TABLEAU 2. Période de capture d'individus en fraie (stade V), selon le sexe et l'espèce, au rapide Farmer's, printemps 1999.

Espèce	Nombre d'individus ♂	Nombre d'individus ♀	Période de capture	Température de l'eau (°C)[1]
Ambloplites rupestris	2	3	27 mai – 10 juin	13,5 – 18,5
Aplodinotus grunniens	1	1	3 – 6 mai	9,0 – 10,0
Carpiodes cyprinus	35	7	29 avril – 3 juin	7,0 – 18,0
Catostomus commersoni	8	5	29 avril – 27 mai	7,0 – 13,5
Hiodon tergisus	198	2	10 mai – 23 juin	12,5 – 19,0
Ichthyomyzon fossor	0	1	23 juin	19,0
Ichthyomyzon unicuspis	2	1	13 mai – 23 juin	12,5 – 19,0
Lampetra appendix	5	3	3 – 20 mai	9,0 – 14,0
Moxostoma anisurum	89	6	3 – 31 mai	9,0 – 17,0
Moxostoma carinatum	96	16	10 mai – 23 juin	12,5 – 19,0
Moxostoma macrolepidotum	67	7	29 avril – 21 juin	7,0 – 19,0
Percina caprodes	10	0	6 – 25 mai	10,0 – 14,0
Percina copelandi	7	1	20 mai – 21 juin	14,0 – 19,0
Percopsis omiscomaycus	0	2	6 mai	10,0
Pomoxis nigromaculatus	3	3	3 – 13 mai	9,0 – 12,5
Semotilus corporalis	1	1	3 – 20 mai	9,0 – 14,0

[1] Température de l'eau au début et à la fin de la période de capture.

stade de maturité IV étaient présents au début de la période d'échantillonnage, le 29 avril, sauf pour les femelles du Chevalier rouge et les mâles du Chevalier de rivière. Pour ceux-ci, les individus au stade IV sont apparus le 3 et le 6 mai respectivement (Figure 3). Des mâles de stade IV ont été capturés jusqu'au 17 mai dans le cas du Chevalier rouge, jusqu'au 27 mai pour le Chevalier blanc et jusqu'au 7 juin pour le Chevalier de rivière. Les dernières femelles de stade IV de Chevaliers rouge et blanc ont été capturées le 17 mai, alors qu'elles ont été présentes sur le site jusqu'au 17 juin pour le Chevalier de rivière.

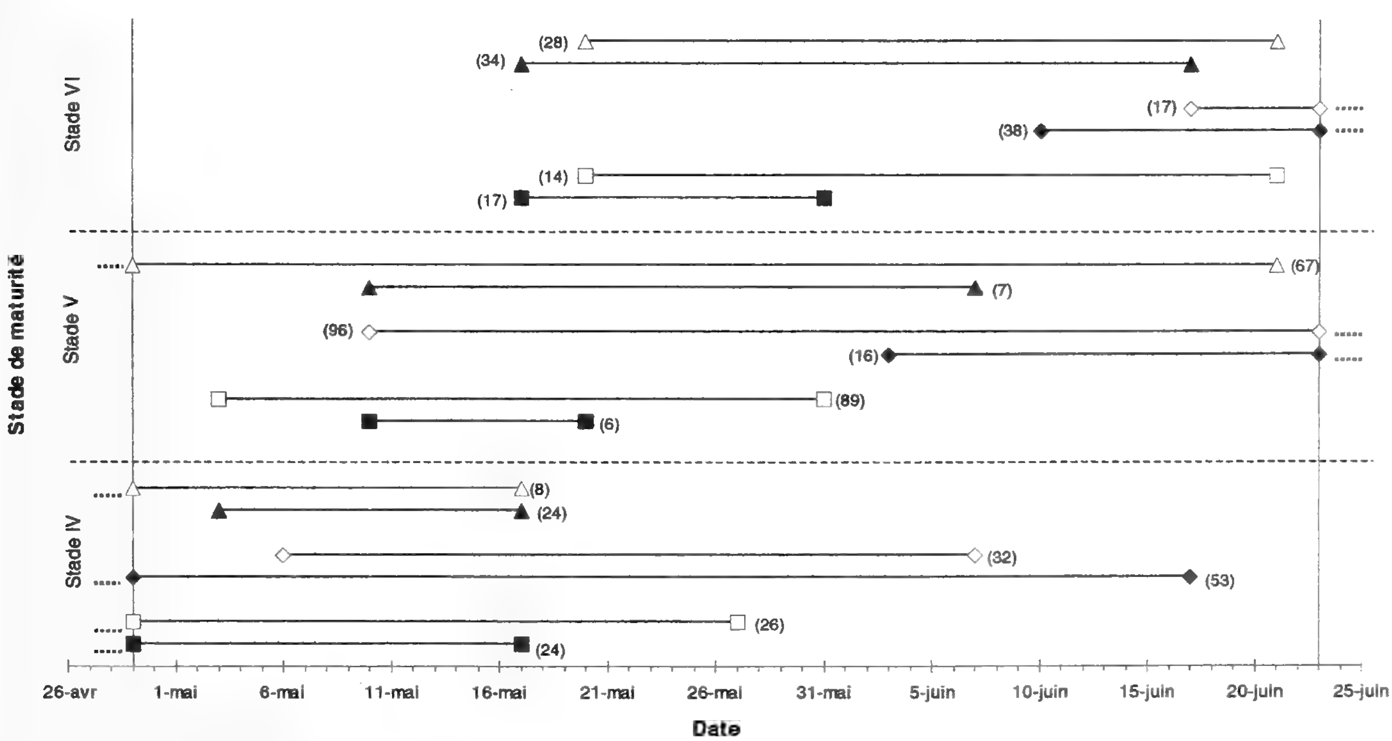

FIGURE 3. Période de reproduction des trois espèces de chevalier selon l'index de maturité de Nikolsky (1963) dans la rivière Gatineau, au printemps 1999. Le carré représente le Chevalier blanc (■), le losange, le Chevalier de rivière (◆) et le triangle, le Chevalier rouge (▲). Les symboles pleins désignent les femelles tandis que les vides représentent les mâles. Le nombre d'individus capturés est indiqué entre parenthèses. Les lignes verticales correspondent au début et à la fin de la période d'échantillonnage. Le pointillé à l'extérieur de la période d'échantillonnage signifie que des individus appartenant aux stades indiqués ont pu se retrouver sur la frayère avant ou après cette période.

Des mâles au stade V sont apparus dans les captures le 3 mai pour le Chevalier blanc et le 10 mai pour le Chevalier de rivière, à une température de 9,0 et 12,5 °C respectivement. Les mâles Chevalier rouge de ce stade de maturité étaient présents dès le début de l'échantillonnage. Les femelles de stade V sont apparues le 10 mai pour le Chevalier blanc et le Chevalier rouge (12,5 °C) et le 3 juin pour le Chevalier de rivière (18,0 °C). Les captures de mâles au stade V sont toujours nettement plus abondantes que celles des femelles. Aucune femelle de stade V n'a été capturée après le 20 mai dans le cas du Chevalier blanc (14,0 °C) et le 7 juin dans le cas du Chevalier rouge (18,5 °C) alors qu'elles étaient toujours présentes à la fin de l'échantillonnage, le 23 juin, dans le cas du Chevalier de rivière, à une température de 19,0 °C.

Des femelles au stade VI apparaissent dans les captures le 17 mai pour le Chevalier blanc et le Chevalier rouge (12,5 °C) alors qu'elles sont présentes pour le Chevalier de rivière à compter du 10 juin (18,5 °C). Les dernières femelles de stade VI ont été capturées le 31 mai pour le Chevalier blanc (17,0 °C) et le 17 juin pour le Chevalier rouge (19,0 °C), alors qu'elles étaient toujours présentes à la dernière date d'échantillonnage pour le Chevalier de rivière (19,0 °C).

Discussion

Si l'on ajoute aux 16 espèces citées dans le Tableau 2 celles rapportées par Houde et Fournier (1992), il est probable qu'environ 20 espèces se reproduisent dans le rapide Farmer's. D'autres espèces capturées pourraient potentiellement utiliser le secteur échantillonné de la rivière Gatineau pour frayer (Scott et Crossman 1974; Bernatchez et Giroux 2000) : le Méné émeraude, le Naseux des rapides, et possiblement le Méné à nageoires rouges et le Raseux-de-terre gris. Toutefois, la période d'échantillonnage ne correspondait pas à la période de fraie pour certaines espèces (e.g. Méné émeraude) alors que trop peu de spécimens ont été capturés pour d'autres afin de déterminer l'état reproductif (e.g. Naseux des rapides).

La frayère multispécifique des rapides de la rivière Gatineau compte autant d'espèces que celle de la rivière aux Pins, à Boucherville (Massé et al. 1988). Les deux frayères ont toutefois des caractéristiques très différentes; la frayère de la rivière aux Pins constitue un habitat d'eau calme utilisé particulièrement par les espèces phytophyles. D'ailleurs, seulement trois espèces sont communes aux deux frayères : la Ouitouche, le Meunier noir et le Crapet de roche. Dans les eaux vives, Massé et al. (1988) mentionnent cinq autres frayères entre Carillon (rivière des Outaouais) et la rivière des Prairies qui comptent entre 8 et 27 espèces reproductrices. La rivière Gatineau se situe donc dans le milieu du peloton quant à son utilisation multispécifique.

Des femelles en état de fraie de Chevaliers rouge et blanc sont apparues sur le site en même temps le 10 mai. Elles y ont été capturées pendant une période de 10 jours dans le cas du Chevalier blanc et de 28 jours dans le cas du Chevalier rouge. La fraie des deux espèces a donc été en partie simultanée (Figures 3 et 4).

Contrairement à nos résultats, Curry et Spacie (1984) ont noté que le Chevalier blanc a amorcé la reproduction une semaine avant le Chevalier rouge dans le Deer Creek, Indiana, en 1979. Toutefois, Mongeau et al. (1986, 1992) ont également observé une simultanéité de la reproduction du Chevalier blanc et du Chevalier rouge dans leur étude sur la rivière Richelieu. En effet, ils ont observé que la reproduction de ces deux espèces débutait à la mi-mai pour se terminer à la mi-juin. Nos données semblent tendre vers le même résultat puisque des individus de stade VI ont été capturés du 17 mai au 21 juin pour les deux espèces (Figure 3). Mongeau et al. (1986, 1992) ont noté que le Chevalier rouge et le Chevalier blanc commençaient à déposer des œufs à une température de 10,7 °C. Meyer (1962) a indiqué que la température à laquelle la reproduction débutait pour le Chevalier rouge et le Chevalier blanc sur la rivière Des Moines, en Iowa, était 11,1°C et 13,3°C respectivement. Par contre, Burr et Morris (1977) ont observé une température de 16,0°C pour la reproduction du Chevalier rouge dans le ruisseau Big Rock, en Illinois et Hackney et al. (1970), une température de 14,4°C pour le Chevalier blanc dans la rivière Flint, en Alabama. La Figure 2 montre que la température de l'eau au 17 mai était à 12,5°C, ce qui correspond relativement bien aux données de Meyer (1962) et de Mongeau et al. (1986, 1992).

Burr et Morris (1977) indiquent que plusieurs espèces de chevaliers pourraient possiblement frayer à des périodes et des températures similaires et sur des substrats comparables. Il peut toutefois y avoir de la ségrégation spatiale entre les espèces. En effet, le Chevalier rouge et le Chevalier doré (*Moxostoma erythrurum*) ont été observés en train de frayer simultanément au même site, mais le Chevalier doré avait une distribution plus étendue en amont, ce qui lui fournissait un habitat non utilisé par le Chevalier rouge (Curry et Spacie 1984). Par ailleurs, une étude comparant la fraie chez le Chevalier doré et le Chevalier noir (*Moxostoma duquesnei*) a démontré que ces deux espèces se reproduisaient au même moment et dans la même section du Stony Creek, en Illinois (Kwak et Skelly 1992). Les auteurs mentionnent toutefois qu'il existe des différences dans le choix des microhabitats de fraie et dans le comportement reproducteur et que celles-ci serviraient possiblement à réduire la compétition entre ces espèces. Bien qu'une étude plus approfondie de l'habitat et du comportement reproductif soit nécessaire, il est possible qu'une ségrégation spatiale et/ou comportementale se produise pour le Chevalier blanc et le Chevalier rouge dans la rivière Gatineau.

Des femelles de stade V du Chevalier de rivière ont été capturées pour la première fois le 3 juin et ce, jusqu'à la dernière journée d'échantillonnage. Sa re-

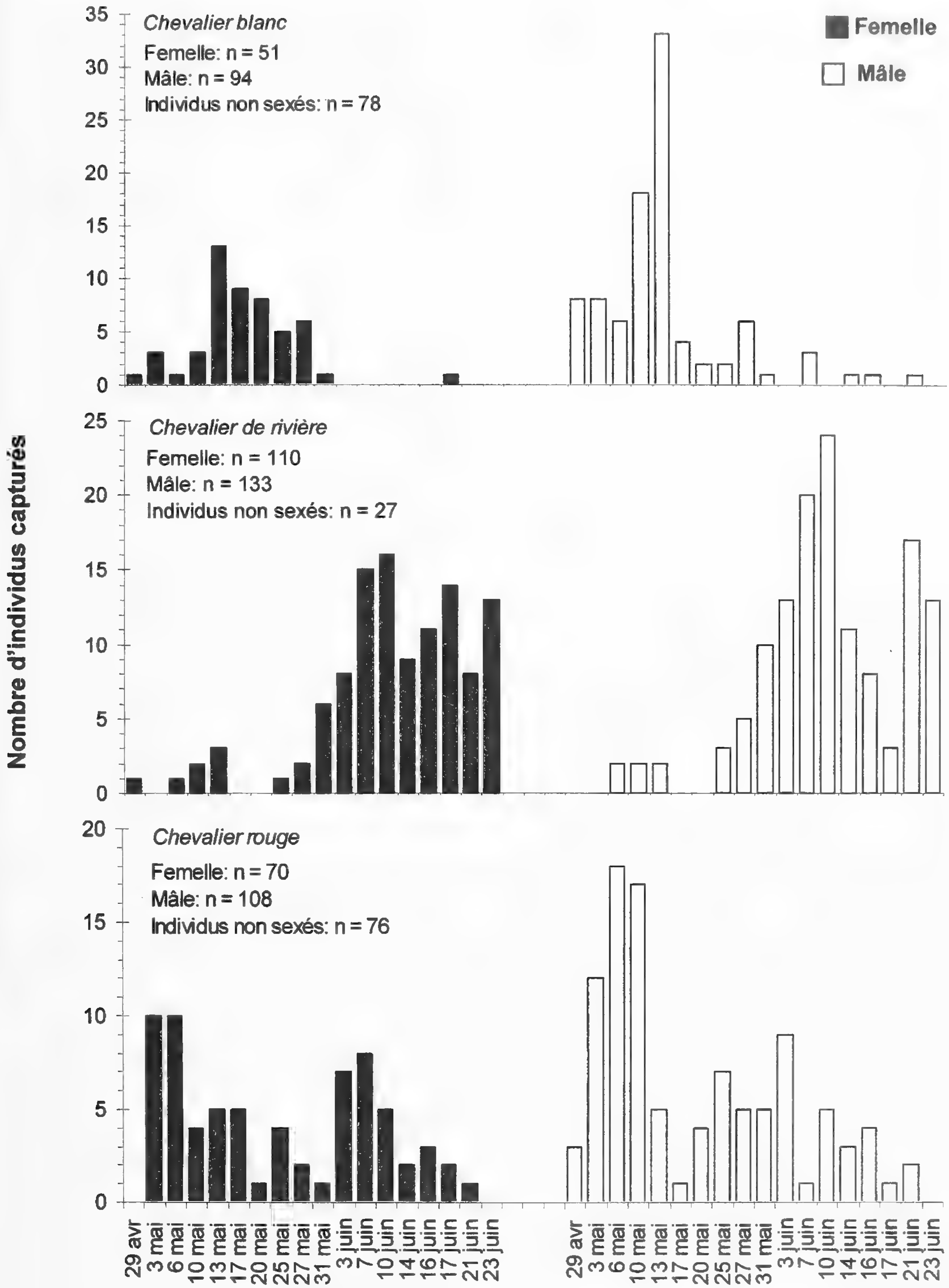

FIGURE 4. Nombre d'individus capturés par jour selon le sexe pour les trois espèces de chevalier, rivière Gatineau, printemps, 1999.

production débute donc plus tard, soit autour du 10 juin (Figure 3) à une température de 18,5 °C. Mongeau et al. (1986, 1992) ont obtenu plus ou moins les mêmes résultats puisqu'ils indiquent que le Chevalier de rivière amorce la fraie autour de la deuxième semaine de juin à une température de 17,7 °C, une conclusion fondée sur la capture de deux spécimens au stade VI. Hackney et al. (1970) mentionnent également que le Chevalier de rivière a une reproduction tardive vis-à-vis de celle du Chevalier blanc dans la rivière Duck, au Tennessee. La différence entre la période de reproduction de cette espèce et celles des deux autres chevaliers présents dans les rapides de la rivière Gatineau est probablement due au fait que le Chevalier de rivière nécessite une température de l'eau plus élevée pour débuter sa reproduction.

Par ailleurs, pour ces trois espèces, nous observons des mâles de stade V à une date plus hâtive que les femelles au même stade (Figure 3). Ceci s'explique par le fait que les mâles du Chevalier blanc, du Chevalier rouge et du Chevalier de rivière précèdent les femelles sur les frayères (Meyer 1962; Hackney et al. 1968, 1970; Scott et Crossman 1974). Ce phénomène est d'ailleurs observé chez d'autres chevaliers et chez plusieurs autres Catostomidae (Meyer 1962; Scott et Crossman 1974; Jenkins et Jenkins 1980; Page et Johnston 1990; Kwak et Skelly 1992; Cooke et Bunt 1999).

Dans nos captures, le nombre de mâles de stade V est plus grand que celui de femelles pour les trois espèces de chevalier. Ceci n'est pas inhabituel. Hackney et al. (1970) ont observé un rapport des sexes de 4 mâles : 1 femelle sur une frayère de Chevalier blanc. De plus, Meyer (1962) note que chez les Chevaliers rouge et blanc, les femelles demeurent sur les sites de fraie beaucoup moins longtemps que les mâles. La fraie chez les chevaliers, et chez la plupart des Catostomidae, se fait généralement en présence de deux mâles et d'une femelle (Hackney et al. 1968; Burr et Morris 1977; Jenkins et Jenkins 1980; Page et Johnston 1990; Kwak et Skelly 1992; Cooke et Bunt 1999), d'où la nécessité d'une présence en plus grand nombre de mâles sur la frayère tel que nous l'avons observé pour chacune des trois espèces présentes au rapide Farmer's.

Nos travaux ont permis de découvrir le site de reproduction de l'une des plus importantes populations de Chevalier de rivière. Un échantillonnage sur quelques années serait nécessaire pour préciser la chronoséquence de fraie de cette espèce et des autres chevaliers utilisant le site. Un échantillonnage sur une plus longue période aurait probablement pu permettre de confirmer la fraie au rapide Farmer's d'un plus grand nombre d'espèces.

Cette étude démontre donc que le rapide Farmer's constitue une frayère multispécifique importante tant par le nombre d'espèces qui s'y reproduisent que par la présence d'espèces évaluées par le COSEPAC comme ayant une situation préoccupante (Lamproie du nord, Chevalier de rivière) ou même menacée (Fouille-roche gris). Localisés en plein coeur d'une zone urbaine, ces rapides ont une grande valeur écologique et doivent être protégés.

Remerciements

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Moths and Butterflies (Lepidoptera) of the Boreal Mixedwood Forest near Lac La Biche, Alberta, Including New Provincial Records

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Lepidoptera were collected, primarily via UV light trap, for three seasons in the boreal mixedwood forest near Lac La Biche, Alberta. A total of 11 111 specimens were collected, representing 41 families and 438 species. A species list with flight times is presented. The total Lepidoptera community was estimated to be 546 ±23.34 species. Abundance and species richness peaked in late July. Thirty-five species constitute new records for Alberta, while one species, *Acanthopteroctetes bimaculata*, is a new record for Canada, and the first record of the family Acanthopteroctetidae in Canada.

Key Words: Moths, butterflies, Lepidoptera, Lac La Biche, Alberta, flight times, *Acanthopteroctetes bimaculata,* new to Canada.

Alberta is blessed with an abundance and variety of forested lands. A large portion of the province is covered by the boreal mixedwood (Figure 1) dominated by Trembling Aspen (*Populus tremuloides*), Balsam Poplar (*P. balsamifera*), and White Spruce (*Picea glauca*) and containing lesser amounts of White Birch (*Betula papyrifera*), Balsam Fir (*Abies balsamea*), and other species (Beckingham and Archibald 1996). Over the last 15 years Trembling Aspen has increased greatly in value as a commercial tree species and there has been a large increase in forestry activity centered on this resource. A large portion of Alberta's aspen mixedwood forest is now scheduled for harvesting over the next 30-40 years (Pratt and Urquhart 1994). It is a major concern that our knowledge of these forests is relatively poor and there is little empirical basis for predicting the impacts of harvesting and other development on non-timber values such as biodiversity.

In an effort to obtain baseline data for assessing impacts of forestry practices on biodiversity, and to determine whether old aspen stands in mixedwood forests contain unique species, a multi-agency team of scientists studied the structure and composition of biotic assemblages in aspen-dominated forests of various ages in the vicinity of Lac La Biche, Alberta, between 1993 and 1995. This work is among the most comprehensive biotic inventories in aspen forests in the province. Lists of plants, birds, amphibians, and mammals have been published by Stelfox (1995) and those of ground-dwelling beetles and dead wood-inhabiting beetles by Spence et al. (1997) and Hammond (1997), respectively. As part of that study, butterflies and moths were also sampled. This represents the first concerted effort to inventory Lepidoptera, especially moths, in aspen forests in western Canada. Lepidoptera constitute a major component of boreal forest biodiversity (Danks and Foottit 1989), and are important herbivores and pollinators (Scoble 1992). The abundance of new provincial records among micromoths (defined here as the primitive and monotrysian groups, and the lower ditrysian superfamilies up to and including the Pyraloidea and Thyridoidea sensu Kristensen 1999) indicates how poorly sampled these groups have been. The attached checklist and flight times provide baseline information for comparison to other studies and to aid in future research.

Materials and Methods

The study area (Figure 1) is located in Lakeland Provincial Park near Touchwood Lake, east of Lac La Biche (54°51'N, 111°27'W) in the Central Mixedwood subregion of the Boreal Forest Natural Region (Beckingham and Archibald 1996). Lepidoptera were sampled in two stands: a 65-year-old ("mature") stand of 269 Ha, containing 83% cover of Trembling Aspen, 15% Balsam Poplar, 2% willow (*Salix* spp.), and 1% White Birch, and a stand over 130 years old ("old") of 148 Ha, containing 54% cover of Trembling Aspen, 32% White Birch, 11% Balsam Poplar, and 3% willow. An inventory of vascular plants found around these study sites is included in the lists published by Stelfox (1995). Both stands were of fire origin, and were largely undisturbed by humans. The mature stand is considered to be of rotation age and the old stand is much

FIGURE 1. Extent of the boreal mixed wood ecoregion in Alberta and location of the study area.

older than the planned stand rotation age (60-70 years) for Alberta aspen forests. A comparison between these two stands, based on the light trap catches of Lepidoptera described here, has been done elsewhere (Pohl et al. 2004).

Two 30 watt UV traps were run in each stand, from dusk to dawn for one night approximately every two weeks, from 16 June to 16 September in 1993, 3 May to 5 October in 1994, and 28 May to 28 August in 1995. Traps were hung at approximately 1.6 m from the ground, and activated from dusk until dawn. These samples were augmented by periodic hand collecting at portable UV lights, and a small amount of net collecting of day-flying species. Specimens were identified using a wide array of taxonomic publications, and by comparing to specimens in the Canadian Forest Service's Northern Forestry Centre Research Collection (NFRC) in Edmonton, Alberta, and the Canadian National Collection (CNC) in Ottawa, Ontario. Voucher specimens have been deposited at the NFRC and CNC.

To obtain an estimate of the total size of the Lepidoptera community in the study area, a Chao-1 estimate of diversity (Chao and Lee 1992) was calculated as described by Colwell and Coddington (1994).

TABLE 1. Abundance and diversity of three groups of Lepidoptera collected near Touchwood Lake, Alberta. Butterflies include the superfamilies Hesperioidea and Papilionoidea; macro-moths include the superfamilies Lasiocampoidea, Bombycoidea, Drepanoidea, Geometroidea, and Noctuoidea; micro-moths comprise all other superfamilies.

Group	Number of Specimens (Proportion)		Number of Species (Proportion)	
micro-moths	3897	(0.350)	201	(0.470)
macro-moths	7163	(0.643)	229	(0.523)
butterflies	51	(0.005)	8	(0.018)
total	11 111		438	

Results

A total of 11 111 specimens were collected, representing 41 families and 438 species (Table 1). A list of all species collected appears in Table 2. Some species, particularly micro-moths, are identified here merely as morphospecies, reflecting the lack of knowledge of the group, and the difficulty in making species identifications. Examples of some of the micro-moth species collected appear in Figure 2; some of the macro-moths are illustrated in Figures 3 and 4. The Chao-1 calculation estimated the total size of the Lepidoptera community in the study area to be 546 ± 23.34.

The 1994 data is examined in detail here, since it was the most extensively sampled year and there were no trap failures. In 1994, both abundance (Figure 5) and species richness (Figure 6) peaked dramatically in late July. A major flush of Noctuidae occurred in late July, with the highest species richness occurring throughout July and into early August. There were modest peaks of noctuid species that overwinter as adults, in early May and mid-September. The Geometridae and other macro-moths peaked slightly earlier than the Noctuidae, exhibiting maximum abundance in early July, and the greatest richness from mid-June to late July. The abundance of micro-moths peaked in late July, although most of this dramatic peak was a single species, *Scoparia biplagialis*, with 846 specimens. The greatest micro-moth richness occurred throughout July. More modest peaks in micro-moth abundance and richness occurred in mid-June and mid-September.

Discussion

This study likely did not collect all the species present in the study area; the Chao-1 estimator suggests that approximately 110 species were missed. Many of these are undoubtedly species that are not easily sampled via light traps. For example, the amount of effort spent collecting butterflies and day-flying moths was minimal and many of these taxa were likely missed.

TABLE 2. List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
Acanthopteroctetidae	*Acanthopteroctetes bimaculata*	Davis	4	early June
Hepialidae	*Korscheltellus gracilis*	(Grote)		mid July
Nepticulidae	*Stigmella* species[1]		1	late July
Adelidae	*Adela purpurea*	Walker		mid May
Prodoxidae	*Greya politella*	(Walsingham)	2	late May
Tineidae	*Nemapogon acapnopennella*	(Clemens)	4	late June – mid July
	Nemapogon species near *acapnopennella*	(Clemens)	2	mid July
	Nemapogon roburella	(Dietz)	2	late June
	Homosetia fasciella	(Chambers)	4	mid July
	Niditinea orleansella	(Chambers)	4	mid July – early August
	Monopis spilotella	Tengström		mid July – early August
	Monopis laevigella	(Denis & Schiffermüller)	2	late June – late July
Bucculatricidae	*Bucculatrix canadensisella*	Chambers		mid July
	Bucculatrix species[1]		1	late July
	Bucculatrix species[2]		1	early June
Gracillariidae	*Caloptilia alnivorella*	(Chambers)		mid May – mid September
	Caloptilia anthobaphes	(Meyrick)	4	mid June – mid July
	Caloptilia betulivora	McDunnough	4	mid May – mid September
	Caloptilia canadensisella	(McDunnough)	4	late June
	Caloptilia coroniella	(Clemens)	4	early June
	Caloptilia stigmatella	(Fabricius)	4	mid May – mid September
	Parectopa pennsylvaniella	(Engel)	2	late June – early July
	Parornix conspicuella	(Dietz)	2	early June – late July
	Acrocercops astericola	(Frey & Boll)	2	late June
	"*Acrocercops*" new species[1]		3	late August
	Protolithocolletis lathyri	Braun	4	early June – late August
	Phyllonorycter martiella	(Braun)	4	late July
	Phyllonorycter species[1]		1	mid June – mid July
Yponomeutidae	*Swammerdamia caesiella*	(Hübner)		mid June – late June
	Euhyponomeutoides gracilariella	(Busck)		mid May – early June
	Argyresthia abies	Freeman	4	late June
	Argyresthia conjugella	Zeller		mid June – late June
	Argyresthia goedartella	(Linnaeus)		mid July – late July
	Argyresthia oreasella	Clemens		mid July – late August
	Argyresthia pygmaeella	(Hübner)		late June – late July
	Argyresthia species[1]		1	mid June – late June
	Argyresthia species[2]		1	mid June – mid July
	Argyresthia species[3]		1	late June – late July

TABLE 2. *(continued)* List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
Ypsolophidae	*Ypsolopha canariella*	(Walsingham)		mid July – early August
	Ypsolopha dentiferella	(Walsingham)	4	late August
Plutellidae	*Rhigognostis interrupta*	(Walsingham)		late May
	Plutella xylostella	(Linnaeus)		late July
Lyonetiidae	*Lyonetia prunifoliella*	Hübner		mid July
Elachistidae	*Agonopterix gelidella*	(Busck)		early August
	Depressariodes ciniflonella	(Leinig & Zeller)		mid May – early August
	Bibarrambla allenella	(Walsingham)		early June – late June
	Semioscopis inornata	Walsingham		mid May
	Nites betulella	(Busck)		early August – late August
	Elachista adempta	Braun	2	mid July – early August
	Elachista albicapitella	Engel	2	late July
	Elachista species[1]		1	late May
	Blastodacna curvilineella	(Chambers)	4	early June
Oecophoridae	*Polix coloradella*	(Walsingham)		late July
Batrachedridae	*Batrachedra praeangusta*	(Haworth)		mid July – late July
Coleophoridae	*Coleophora pruniella*	Clemens		mid June – late July
	Coleophora persimplexella	McDunnough	4	mid June – late June
	Coleophora corylifoliella	Clemens	4	late July
	Coleophora alnifoliae	Barasch	4	mid June – late July
	Coleophora comptoniella	(McDunnough)	4	late June – mid July
	Coleophora rosaevorella	McDunnough	4	late June – mid July
	Coleophora mcdunnoughiella	Oudejans	4	mid June – late June
	Coleophora duplicis	Braun	4	late July – early August
	Coleophora dextrella	Braun	4	mid July – late July
	Coleophora glaucicolella	Wood	4	late June – late July
	Coleophora mayrella	(Hübner)		mid July
	Coleophora new species[1]		3	late July
	Coleophora new species[2]		3	mid May – late July
	Coleophora new species[3]		3	late July
	Mompha albapalpella	(Chambers)	2	late July
	Mompha terminella	(Westwood)	4	mid June – mid July
	Mompha species[1]		1	mid June – late June
	Mompha species[2]		1	late June
	Mompha species[3]		1	mid June – late June
	Hypatopa titanella	McDunnough	2	mid July – late July
	Asaphocrita species[1]		1	mid June – late June

TABLE 2. *(continued)* List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
Cosmopterigidae	*Limnaecia phragmitella*	Stainton	4	early August
Gelechiidae	*Coleotechnites atrupictella*	(Dietz)	2	early August
	Coleotechnites blastivora	(McLeod)	4	mid May – early June
	Coleotechnites florae	(Freeman)		early May
	Coleotechnites piceaella	(Kearfott)		mid July
	Sinoe new species[1]		3	mid May – late July
	Neotelphusa praefixa	(Braun)		mid July – early August
	Xenolechia aethiops	(Humphreys & Westwood)		early May – mid June
	"*Stenolechia*" species[1]		1	late July
	Teleiodes proximella	Hübner	2	early June – late June
	Bryotropha species[1]		1	late June – late July
	Gelechia dyarella	Busck	4	early August – mid September
	Gelechia lynceella	Zeller	4	mid July – late July
	Gnorimoschema septentrionella	Fyles	4	late August
	Gnorimoschema species near *vastificum*	Braun	2	late July
	Chionodes continuella	(Zeller)		mid July
	Chionodes sattleri	Hodges		early August
	Chionodes lugubrella	(Fabricius)		mid June – early August
	Chionodes mediofuscella	(Clemens)		late May – mid July
	Chionodes occlusus	(Braun)		late June – late July
	Chionodes psilopterus	(Barnes & Busck)		late June – early August
	Chionodes terminimaculella	(Kearfott)		mid May – early August
	Filatima abactella	(Clarke)	2	late May – late June
	Syncopacma species[1]		1	late July
	Anacampsis conclusella	(Walker)	4	late June – late July
	Helcystogramma fernaldella	(Busck)		mid June
	Dichomeris levisella	(Fyles)		late July – early August
Cossidae	*Acossus centerensis*	(Lintner)		late June – early August
	Acossus populi	(Walker)		late June – late July
	Prionoxystus robiniae	(Peck)		mid July
Tortricidae – Tortricinae	*Acleris albicomana*	(Clemens)		late July
	Acleris obligatoria	Park & Razowski		mid May – late May
	Acleris forbesana	(McDunnough)		mid June
	Acleris schalleriana	(Linnaeus)		late August – mid September
	Acleris celiana	(Robinson)		early June
	Acleris britannia	Kearfott		early August – mid September
	Acleris logiana	(Clerck)		early June
	Acleris variana	(Fernald)		late July – early August

TABLE 2. *(continued)* List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
	Acleris nigrolinea	(Robinson)		late August – early June
	Acleris emargana	(Fabricius)		mid September
	Cochylis nana	(Haworth)		late June
	Aethes promptana	(Robinson)	4	late July – early August
	Eulia ministrana	(Linnaeus)		mid June
	Sparganothis xanthoides	(Walker)		early August
	Sparganothis reticulatana	(Clemens)		early August
	Sparganothis species[1]		1	late July
	Platynota idaeusalis	(Walker)		mid July – late August
	Pandemis canadana	Kearfott		mid July – early August
	Choristoneura rosaceana	(Harris)		late July – early August
	Choristoneura albaniana	(Walker)		late May
	Choristoneura conflictana	(Walker)		late June – mid July
	Choristoneura fumiferana	(Clemens)		mid July
	Archips argyrospila	(Walker)		mid July – late July
	Syndemis afflictana	(Walker)		late May
	Clepsis persicana	(Fitch)		late June – early August
	Clepsis clemensiana	(Fernald)		late July
	Clepsis melaleucana	(Walker)		mid June – late July
	Clepsis virescana	(Clemens)		mid June – late August
Tortricidae – Olethreutinae	*Taniva albolineana*	(Kearfott)		mid July
	Apotomis capreana	(Hübner)		early July – early August
	Apotomis deceptana	(Kearfott)		early August
	Apotomis infida	(Heinrich)		late June – mid July
	Apotomis removana	(Kearfott)		late July – early August
	Pseudosciaphila duplex	(Walsingham)		mid July
	Olethreutes glaciana	(Möschler)		mid June – early August
	Olethreutes metallicana	(Hübner)		mid June – late June
	Ancylis subaequana	(Zeller)		late May – late June
	Ancylis species near *laciniana*	(Zeller)	2	mid June – late June
	Ancylis species near *fuscociliana*	(Clemens)	2	late June – mid July
	Ancylis comptana	(Frölich)		late June
	Ancylis diminutana	(Haworth)		late June – mid July
	Retinia burkeana	(Kearfott)		mid July
	Phaneta species near *awemeana*	(Kearfott)	2	mid June
	Phaneta parmatana	(Clemens)		late July
	Phaneta convergana	(McDunnough)	2	late May
	Notocelia culminana	(Walsingham)		late July – early August
	Gypsonoma fasciolana	(Clemens)		mid June – late July

TABLE 2. *(continued)* List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
	Gypsonoma substitutionis	Heinrich		mid June – late July
	Gypsonoma salicicolana	(Clemens)	2	late July
	Gypsonoma adjuncta	Heinrich		mid June – late June
	Zeiraphera canadensis	Mutuura & Freeman		late July
	Zeiraphera fortunana	(Kearfott)	2	mid September
	Zeiraphera unfortunana	Powell		late July
	Pseudexentera oregona	(Walsingham)		early May – mid May
	Griselda radicana	Heinrich		mid September
	Epinotia trigonella	(Linnaeus)		mid July – late August
	Epinotia solandriana	(Linnaeus)		late July – mid September
	Epinotia castaneana	(Walsingham)		mid July – early August
	Epinotia rectiplicana	(Walsingham)		late May – late July
	Epinotia nisella	(Clerck)		late May – mid September
	Epinotia criddleana	(Kearfott)		mid September
	Epinotia transmissana	(Walker)		late June – mid July
	Epinotia momonana	(Kearfott)	2	late July – late August
	Epinotia lindana	(Fernald)		late August – mid September
	Grapholita lunatana	Walsingham		early May – late May
	Cydia populana	(Busck)		late May – late July
	Cydia flexiloqua	(Heinrich)		mid July
Choreutidae	*Caloreas occidentella*	(Dyar)		mid June
	Choreutis diana	(Hübner)		late July
Urodidae	*Wockia asperipunctella*	(Bruand)	4	early June – late June
Alucitidae	*Alucita* lalannei	Landry & Landry		mid May
Pterophoridae	*Hellinsia homodactylus*	(Walker)		mid July
	Amblyptilia pica	(Walsingham)		early May
Carposinidae	*Bondia crescentella*	(Walsingham)		early May
Pyralidae	*Dolichomia thymetusalis*	(Walker)		mid July
	Acrobasis sp. prob. *betulella*	Hulst	2	late July
	Myelopsis subtetricella	(Ragonot)		late May – early August
	Dioryctria reniculelloides	Mutuura & Munroe		late June – early August
	Zophodia grossulariella	(Hübner)		early May – early June
	Eulogia ochrifrontella	(Zeller)		late June – early August
Crambidae	*Scoparia biplagialis*	Walker		mid July – late August
	Eudonia albertalis	(Dyar)		mid July – early August
	Crambus perlellus	(Scopoli)		late July – late August
	Crambus leachellus	(Zincken)	4	early August
	Agriphila ruricolella	(Zeller)		late July
	Agriphila vulgivagella	(Clemens)		late July

TABLE 2. *(continued)* List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
	Pediasia dorsipunctella	(Kearfott)		mid July – late July
	Synclita obliteralis	(Walker)		mid June – early August
	Parapoynx maculalis	(Clemens)	4	mid June
	Evergestis pallidata	(Hufnagel)		late July
	Perispasta caeculalis	Zeller		late June
	Phlyctaenia coronata	(Hufnagel)		mid June – mid July
	Pyrausta nicalis	(Grote)		early June
	Pyrausta borealis	Packard		late May – early July
	Udea itysalis	(Walker)		late June – early August
	Choristostigma plumbosignale	(Fernald)		mid July – early August
Hesperiidae	*Carterocephalus palaemon*	(Pallas)		late June
Papilionidae	*Papilio canadensis*	Rothschild & Jordan		late May – late July
Pieridae	*Pieris oleracea*	Harris		late June
Lycaenidae	*Everes amyntula*	(Boisduval)		late June
Nymphalidae	*Polygonia satyrus*	(Edwards)		early May – mid May
	Nymphalis antiopa	(Linnaeus)		early October – late June
	Aglais milberti	(Godart)		late June – late August
	Basilarchia arthemis	(Drury)		late June – early August
Drepanidae	*Habrosyne scripta*	(Gosse)		mid June – mid July
	Pseudothyatira cymatophoroides	(Guenée)		mid July
	Euthyatira pudens	(Guenée)		mid May – early June
	Drepana arcuata	Walker		late May – early August
	Drepana bilineata	(Packard)		late May – mid July
	Oreta rosea	(Walker)		late June – mid July
Geometridae – Ennominae	*Protitame virginalis*	(Hulst)		mid June – mid July
	Macaria brunneata	(Thunberg)		mid July – late July
	Macaria loricaria	(Eversman)		mid July – early August
	Macaria bitactata	(Walker)		late June – early August
	Macaria ulsterata	(Pearsall)		mid May – mid July
	Macaria signaria	(Hübner)		early June – mid July
	Digrammia rippertaria	(Duponchel)		late June
	Orthofidonia exornata	(Walker)		mid May – early June
	Aethalura intertexta	(Walker)		mid May
	Iridopsis larvaria	(Guenée)		late May – mid July
	Ectropis crepuscularia	(Denis & Schiffermüller)		mid May – early June
	Protoboarmia porcelaria	(Guenée)		late June – early August
	Biston betularia	(Linnaeus)		mid June – mid July
	Lycia ursaria	(Walker)		early May

TABLE 2. *(continued)* List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
	Erannis tiliaria	(Harris)		mid September – early October
	Cabera erythemaria	Guenée		mid June – early August
	Cabera variolaria	Guenée		mid June – mid July
	Euchlaena obtusaria	(Hübner)		mid July
	Euchlaena marginaria	(Minot)		late May
	Euchlaena tigrinaria	(Guenée)		late June – early August
	Xanthotype sospeta	(Drury)		mid July – early August
	Pero honestaria	(Walker)		mid June – early July
	Campaea perlata	(Guenée)		mid July – late August
	Ennomos magnaria	Guenée		early August – mid September
	Selenia alciphearia	Walker		mid May – early June
	Metanema inatomaria	Guenée		late May – early August
	Metanema determinata	Walker		early June – late June
	Plagodis pulveraria	(Linnaeus)		late May
	Plagodis phlogosaria	(Guenée)		mid May – late June
	Plagodis alcoolaria	(Guenée)		late May – late June
	Caripeta divisata	Walker		mid June – late July
	Besma quercivoraria	(Guenée)		late May – mid July
	Lambdina fiscellaria	(Guenée)		late August – mid September
	Sicya macularia	(Harris)		mid July – early August
	Nematocampa resistaria	(Herrich-Schäffer)		late July – early August
Geometridae – Sterrhinae	*Idaea rotundopennata*	(Packard)		late June
	Cyclophora pendulinaria	(Guenée)		late May – late July
	Scopula limboundata	(Haworth)		mid July – early August
	Scopula ancellata	(Hulst)		mid July
	Scopula junctaria	(Walker)		late June – late July
	Scopula frigidaria	(Möschler)		mid June – early August
Geometridae – Larentiinae	*Dysstroma citrata*	(Linnaeus)		early August – mid September
	Dysstroma truncata	(Hufnagel)		mid July
	Dysstroma walkerata	(Pearsall)		late June – late August
	Dysstroma hersiliata	(Guenée)		late May – early August
	Dysstroma formosa	(Hulst)		mid June – early August
	Eulithis propulsata	(Walker)		mid July – early August
	Eulithis explanata	(Walker)		mid July – late August
	Eulithis xylina	(Hulst)		mid July – early August
	Ecliptopera silaceata	(Denis & Schiffermüller)		early June – mid July
	Plemyria georgii	Hulst		early August
	Hydriomena perfracta	Swett		late May – late July

TABLE 2. *(continued)* List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
	Hydriomena renunciata	(Walker)		late May – late July
	Hydriomena ruberata	(Freyer)		late May – late July
	Hydriomena furcata	(Thunberg)		late July – late August
	Triphosa haesitata	(Guenée)		mid September – early October
	Mesoleuca ruficillata	(Guenée)		early May – mid July
	Spargania luctuata	(Denis & Schiffermüller)		mid June – mid July
	Perizoma basaliata	(Walker)		early July – late July
	Anticlea vasiliata	Guenée		mid May – early June
	Anticlea multiferata	(Walker)		late May
	Xanthorhoe abrasaria	(Herrich-Schäffer)		late June – early August
	Xanthorhoe iduata	(Guenée)		late July
	Xanthorhoe fossaria	Taylor		early June – early August
	Xanthorhoe decoloraria	(Esper)		mid July – early August
	Xanthorhoe ferrugata	(Clerk)		late May – mid July
	Xanthorhoe lacustrata	(Guenée)		mid May – early August
	Epirrhoe alternata	(Müller)		mid June – late July
	Euphyia intermediata	(Guenée)		mid May – late July
	Zenophleps alpinata	Cassino		mid July – late August
	Hydrelia albifera	(Walker)		late June
	Venusia cambrica	Curtis		late May – late August
	Venusia pearsalli	(Dyar)		mid May – mid July
	Trichodezia albovittata	(Guenée)		late May – mid July
	Epirrita autumnata	(Borkhausen)		mid September
	Operophtera bruceata	(Hulst)		early October
	Eubaphe mendica	(Walker)		late June – early August
	Eupithecia columbiata	(Dyar)		late May
	Eupithecia subfuscata	(Haworth)		late May – late June
	Eupithecia satyrata	(Hübner)		late May – late July
	Eupithecia assimilata	Doubleday		late May – early August
	Eupithecia perfusca	(Hulst)		early June – mid July
	Eupithecia stellata	(Hulst)		mid June – late August
	Eupithecia anticaria	Walker		mid June – late June
	Eupithecia ravocostaliata	Packard		mid May – early June
	Acasis viridata	(Packard)		mid May
	Cladara limitaria	(Walker)		mid May – early June
	Cladara atroliturata	(Walker)		early May – mid June
	Lobophora nivigerata	Walker		late June
Uraniidae	*Callizzia amorata*	Packard		mid June – early August
Lasiocampidae	*Phyllodesma americana*	(Harris)		mid May – early July

TABLE 2. *(continued)* List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
	Malacosoma disstria	Hübner		mid July – early August
Sphingidae	*Smerinthus cerisyi*	Kirby		mid May – early August
	Hyles gallii	(Rottemburg)		late June
Notodontidae	*Clostera albosigma*	Fitch		late May – late July
	Clostera strigosa	(Grote)		late May – late June
	Clostera apicalis	(Walker)		late May – late June
	Nadata gibbosa	(J.E. Smith)		mid June
	Pheosia rimosa	Packard		mid May – mid July
	Notodonta simplaria	Graef		late May – early June
	Gluphisia septentrionis	Walker		late May – early August
	Gluphisia avimacula	Hudson		mid May – late May
	Gluphisia lintneri	(Grote)		early May
	Furcula occidentalis	(Lintner)		late May – late June
	Furcula scolopendrina	(Boisduval)		late May – late June
	Furcula modesta	(Hudson)		late June
	Schizura unicornis	(J.E. Smith)		early July
	Schizura leptinoides	(Grote)		late June – early August
Arctiidae	*Eilema bicolor*	(Grote)		mid July – early August
	Clemensia albata	Packard		mid July – early August
	Haploa lecontei	(Guérin-Méneville)		mid July – early August
	Phragmatobia assimilans	Walker		late May – late June
	Platarctia parthenos	(Harris)		mid June – mid July
	Lophocampa maculata	Harris		mid June – late June
Lymantriidae	*Dasychira vagans*	(Barnes & McDunnough)		mid July – late July
	Dasychira plagiata	(Walker)		mid July – late July
Noctuidae – Sarrothripinae	*Nycteola frigidana*	(Walker)		mid May – late August
Noctuidae – Herminiinae	*Idia americalis*	(Guenée)		late June – early August
	Idia aemula	Hübner		mid July – early August
	Idia new species near *aemula*	Hübner	3	mid July – early August
	Phalaenophana pyramusalis	(Walker)		late May – mid July
	Zanclognatha lutalba	(J.B. Smith)		mid July – early August
	Chytolita petrealis	Grote		late May – early August
	Phalaenostola hanhami	(J.B. Smith)	4	late July
	Bleptina caradrinalis	Guenée		mid July
	Palthis angulalis	(Hübner)		late June – mid July
Noctuidae – Strepsimaninae	*Hypenodes fractilinea*	(J.B. Smith)		mid July – early August
Noctuidae – Rivulinae	*Rivula propinqualis*	Guenée		mid July – late July

TABLE 2. *(continued)* List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
Noctuidae – Hypeninae	*Hypena atomaria*	Smith		mid July
	Hypena edictalis	(Walker)		mid July – late August
	Hypena humuli	Harris		mid May
Noctuidae – Catocalinae	*Caenurgina crassiuscula*	(Haworth)		late May
	Catocala relicta	Walker		early August – mid September
	Catocala unijuga	Walker		late July – early October
	Catocala briseis	Edwards		early August – mid September
	Catocala semirelicta	Grote		early August – late August
Noctuidae – Plusiinae	*Abrostola urentis*	Guenée		late June – mid July
	Diachrysia aereoides	(Grote)		late July
	Polychrysia esmerelda	(Oberthür)		early August
	Chrysanympha formosa	(Grote)		late July
	Eosphoropteryx thyatyroides	(Guenée)		late July
	Autographa rubida	Ottolengui		mid June – late June
	Autographa bimaculata	(Stephens)		late July – late August
	Autographa mappa	(Grote & Robinson)		late June – mid July
	Autographa ampla	(Walker)		late June – late July
	Syngrapha octoscripta	(Grote)		late July
	Syngrapha viridisigma	(Grote)		late July – late August
	Syngrapha alias	(Ottolengui)		mid July – late July
	Syngrapha rectangula	(Kirby)		mid July
	Plusia putnami	Guenée		late June – early August
Noctuidae – Eustrotiinae	*Lithacodia albidula*	(Guenée)		mid June – late July
Noctuidae – Acronictinae	*Raphia frater*	Grote		late May – late July
	Acronicta vulpina	Guenée		early June – late June
	Acronicta innotata	Guenée		mid June – early August
	Acronicta grisea	Walker		late May – mid July
	Acronicta fragilis	(Guenée)		late May – early August
	Acronicta impleta	Walker		early June – late June
	Acronicta impressa	Walker		late May – mid June
	Harrisimemna trisignata	(Walker)		mid June
Noctuidae – Cuculliinae	*Homohadena badistriga*	(Grote)		mid July – late August
	Homohadena infixa	(Walker)		late July – late August
Noctuidae – Hadeninae	*Apamea commoda*	(Walker)		early May – late July
	Apamea cogitata	(Smith)		late July – early August
	Oligia mactata	(Guenée)		late August – mid September
	Oligia illocata	(Walker)		late August – mid September
	Parastichtis suspecta	(Hübner)		mid July – late August
	Amphipoea americana	(Speyer)		late August

TABLE 2. *(continued)* List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
	Euplexia benesimilis	McDunnough		early June – late June
	Phlogophora periculosa	Guenée		mid July – early August
	Enargia decolor	(Walker)		late July – mid September
	Enargia infumata	(Grote)		mid July – mid September
	Ipimorpha pleonectusa	Grote		early August – late August
	Chytonix palliatricula	(Guenée)		late May – mid July
	Andropolia contacta	(Walker)		late August
	Hyppa contrasta	McDunnough		mid June – mid July
	Elaphria alapallida	(Pragne & Sullivan)		late May – late June
	Xylena curvimacula	(Morrison)		mid September – mid May
	Lithomoia germana	(Morrison)		late August – mid September
	Homoglaea hircina	Morrison		early October
	Litholomia napaea	(Morrison)		mid September – early June
	Lithophane innominata	(Smith)		early June
	Lithophane petulca	Grote		early June
	Anathix puta	(Grote & Robinson)		early August – mid September
	Xanthia tatago	Lafontaine & Mikkola		mid September
	Hillia iris	(Zetterstedt)		late August
	Platypolia anceps	(Stephens)		mid September
	Xylotype arcadia	Barnes & Benjamin		late August – mid September
	Brachylomia algens	(Grote)		early August – late August
	Brachylomia discinigra	(Walker)		early August – late August
	Polia nimbosa	(Guenée)		mid June – early August
	Polia imbrifera	(Guenée)		mid July – late July
	Melanchra adjuncta	(Guenée)		mid June
	Lacanobia radix	(Walker)		late May
	Lasionycta poca	(Barnes & Benjamin)		late June – late July
	Lacinipolia renigera	(Stephens)		mid July
	Lacinipolia lorea	(Guenée)		late June – early August
	Mythimna oxygala	(Grote)		mid July – late July
	Leucania insueta	Guenée		late June
	Orthosia revicta	(Morrison)		mid May – early June
	Orthosia segregata	(Smith)		mid May
	Orthosia hibisci	(Guenée)		early May – early June
	Egira dolosa	(Grote)		mid May – early June
	Protorthodes oviduca	(Guenée)		early June
Noctuidae – Noctuinae	*Diarsia rubifera*	(Grote)		mid July – late August
	Diarsia dislocata	(Smith)		mid July – early August
	Diarsia rosaria	(Grote)		mid July – late July

TABLE 2. *(concluded)* List of Lepidoptera species collected near Touchwood Lake, Alberta. Higher classification follows that of Kristensen (1999). Species sequence within higher taxa follows the Hodges et al. (1983) checklist. Flight period is based on collections made over the three-year study.

Family	Genus species	Author	Notes	Flight Period
	Graphiphora augur	(Fabricius)		early May – late August
	Eurois occulta	(Linnaeus)		mid July – late August
	Eurois astricta	(Morrison)		mid July – early August
	Megasema c-nigrum	(Linnaeus)		mid July
	Xestia normaniana	(Grote)		late July
	Xestia smithii	(Snellen)		late July – late August
	Pachnobia mixta	(Walker)		late July
	Pachnobia imperita	(Hübner)		early August
	Pseudohermonassa tenuicula	(Morrison)		late July
	Coenophila opacifrons	(Grote)		early August
	Metalepsis salicarum	(Walker)		mid May
	Aplectoides condita	(Guenée)		late May – late July
	Anaplectoides prasina	(Denis & Schiffermüller)		mid July – early August
	Anaplectoides pressus	(Grote)		early May – early August
	Protolampra rufipectus	(Morrison)		late July – late August
	Eueretagrotis perattenta	(Grote)		late June – early August
	Cryptocala acadiensis	(Bethune)		mid July – late July

notes:
[1] state of taxonomic knowledge is insufficient to make a species determination
[2] species determination uncertain
[3] undescribed species
[4] new record for Alberta

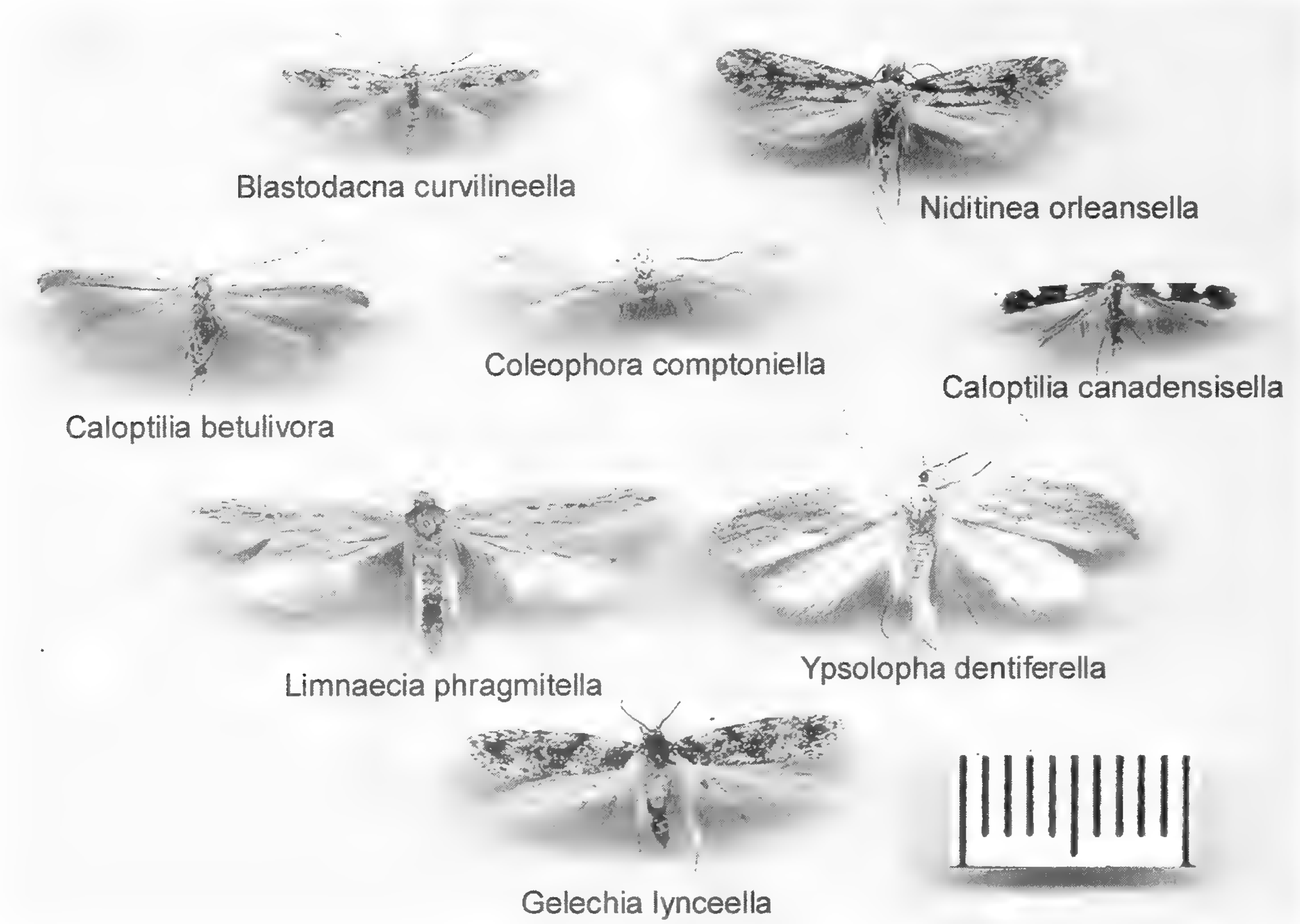

FIGURE 2. Microlepidoptera collected near Touchwood Lake, Alberta. All are new Alberta records. (ruler = 1cm).

The study site lies within the ranges of 67 butterfly species (Bird et al. 1995); many of these certainly occur in the mixedwood habitat but were not collected there. Some nocturnal moths, including some species of Gelechiidae and Oecophoridae (Hodges 1974; Miller 2000), are not attracted to UV light so they would be undersampled as well. If other moth species occur in the area but were not collected, they are probably quite rare, or may be extremely localized in particular micro-habitats, which were not adequately sampled in this study.

Macro-moths comprised a greater proportion of individuals than of species, whereas the micro-moths were particularly species-rich, comprising a greater proportion of species than of individuals. These proportions (Table 1) were similar to those previously reported for the province of Alberta. In his list of Lepidoptera of Alberta, Bowman (1951) reported 40.8% micro-moths (779 species), 50.9% macro-moths (973 species), and 8.3% butterflies (159 species). In the most recent list of Lepidoptera of North America, Poole (1996) listed 49.3% micro-moths (5743 species), 43.9% macro-moths (5114 species), and 6.9% butterflies (801 species). The proportionally higher representation of micro-moth species in the current study compared to Bowman's 1951 list reflects the recent increase in knowledge of the group, including the description of many new species.

A total of 35 positively identified species are new records for the province, and one (*Acanthopteroctetes bimaculata*) is a new record for Canada (Table 2). Micro-moths (Figure 2) make up 34 of these new records; a further five micro-moth species and one macro-moth species represent undescribed species. Details for some of these new records and new species appear below.

Acanthopteroctetes bimaculata Davis (Acanthopteroctetidae):

This primitive moth is known previously from California and Oregon (Davis 1978). The current record represents the first report of this moth, and of the family Acanthopteroctetidae, occurring in Canada. Nothing is known of its biology.

Caloptilia anthobaphes (Meyrick) (Gracillariidae):

Previously reported from northern Ontario (Forbes 1923). Nothing is known of its biology.

Caloptilia betulivora McDunnough (Gracillariidae) (Figure 2):

Previously reported first only from Nova Scotia (McDunnough 1946) and since been reported from Quebec (Handfield et al. 1997). It likely occurs across the boreal zone in Canada. Larvae feed in the folded leaves of birch.

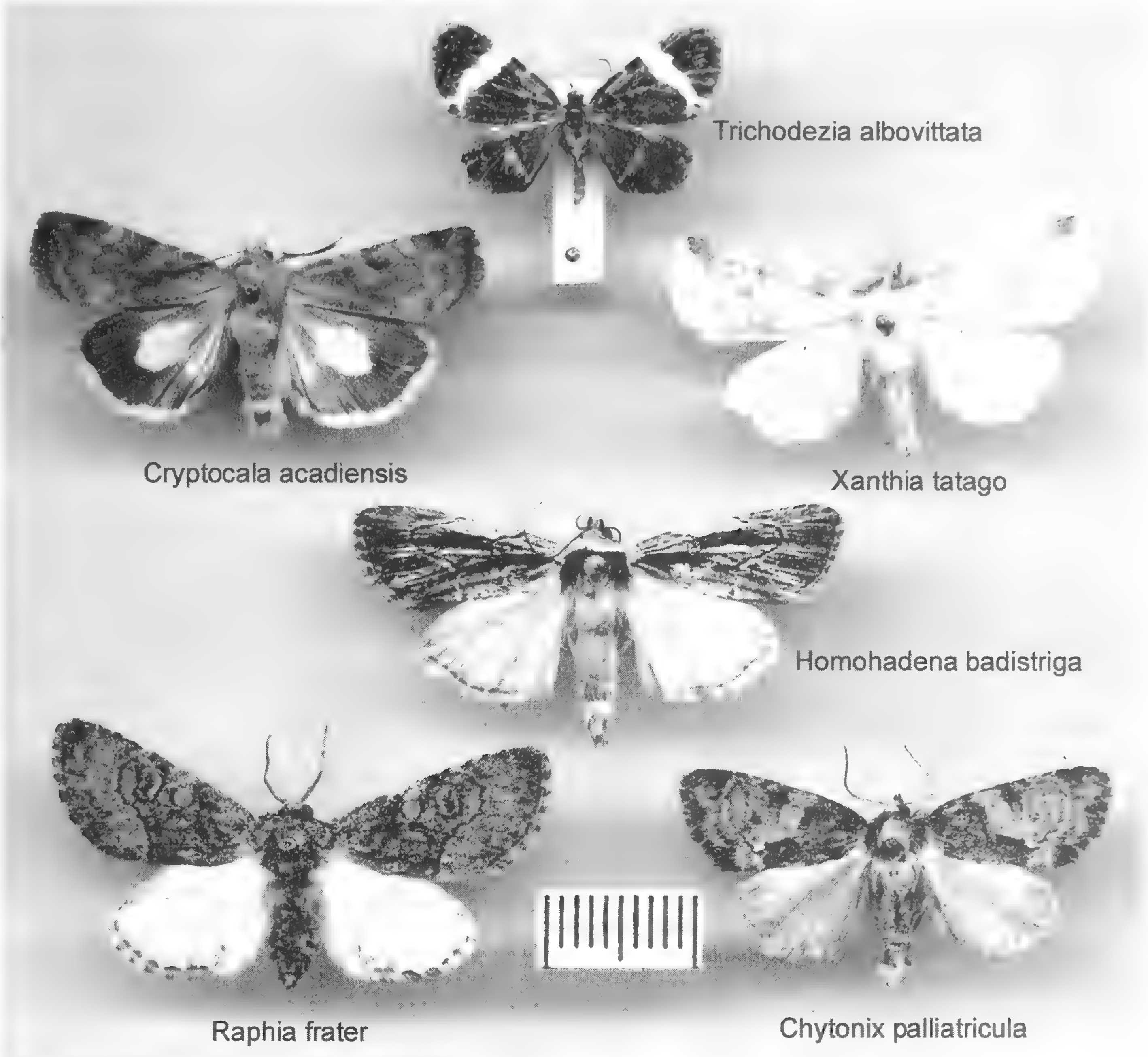

FIGURE 3. An assortment of macrolepidoptera collected from mature aspen forest near Touchwood Lake, Alberta (ruler = 1 cm).

Caloptilia canadensisella (McDunnough) (Gracillariidae) (Figure 2):

Originally described from Nova Scotia (McDunnough 1956). It has since been reported in Quebec (Handfield et al. 1997; Landry and Landry 1992), and is probably widely distributed but uncollected across the boreal forest. The larvae make large blotch mines on the leaves of Bunchberry (*Cornus canadensis*).

Caloptilia coroniella (Clemens) (Gracillariidae):

Previously known only from the midwestern U.S.A. (Forbes 1923). Larvae feed on birch.

Caloptilia stigmatella (Fabricius) (Gracillariidae):

Not reported from western Canada, but GRP [Greg R. Pohl] has collected it quite commonly in Alberta and Saskatchewan. Larvae feed on willow (Forbes 1923).

Argyresthia abies Freeman (Yponomeutidae):

Reported in eastern Canada only as far west as northern Ontario (Freeman 1972) but is probably widely distributed across western North America in the boreal forest. It is a twig borer on Balsam Fir (*Abies balsamea*).

Coleophora corylifoliella Clemens (Coleophoridae):

Previously reported only in eastern North America (Forbes 1923). Larvae there feed on *Corylus americana*; in the west they probably feed on Beaked Hazelnut (*Corylus cornuta*).

Coleophora duplicis Braun (Coleophoridae):

Previously known from eastern Canada and the midwestern United States (Forbes 1923; Handfield et al. 1997). It feeds on the seeds of Aster (*Aster* spp.) and Goldenrod (*Solidago* spp.).

Limnaecia phragmitella Stainton (Cosmopterigidae) (Figure 2):

A holarctic species. The closest it has been reported to Alberta is Wyoming (Hodges 1978). However, collection records (CNC, NFRC) indicate that the species is transamerican. Recent collections made by GRP indicate that it is common in western Canada, at sites where its host plant, Com-

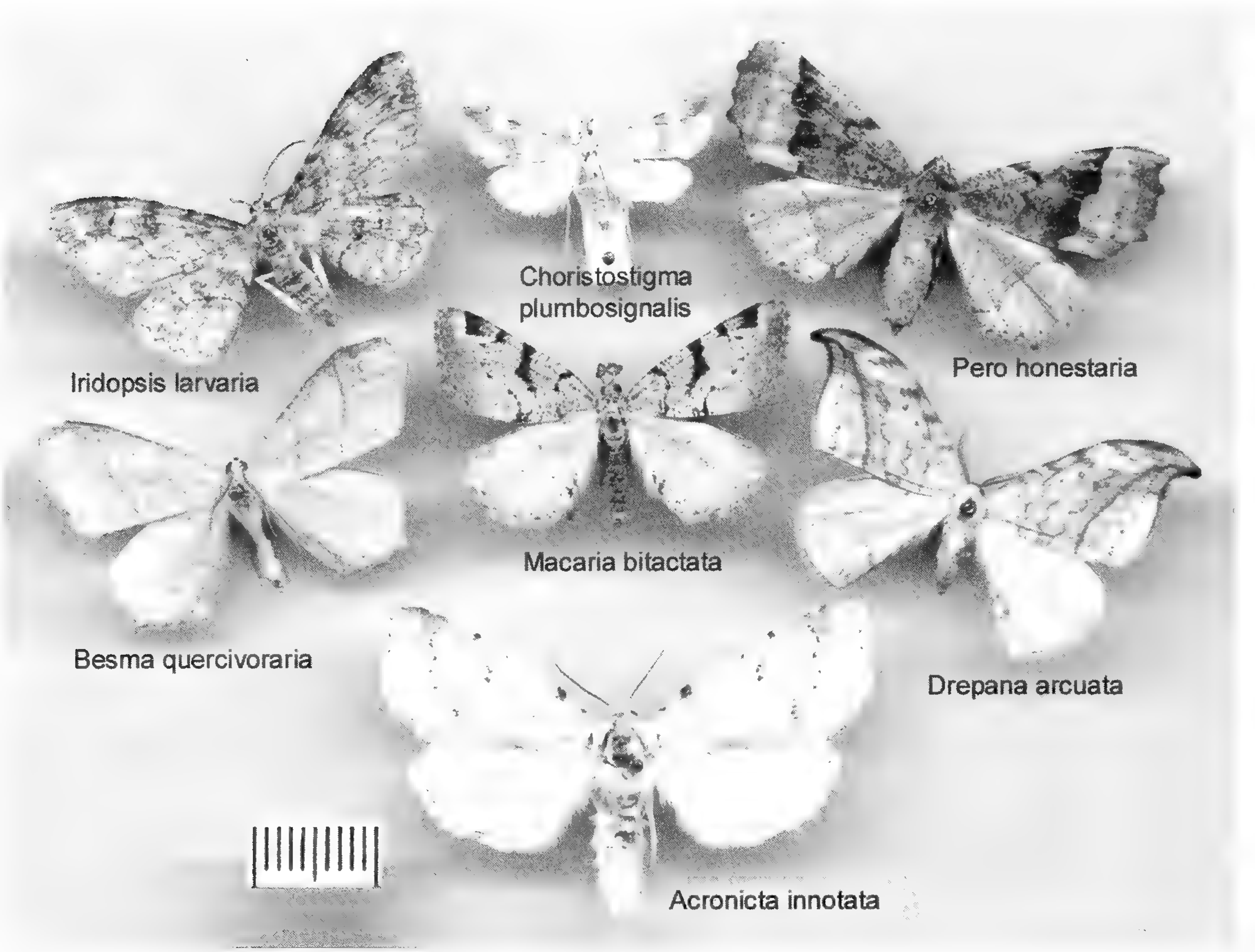

FIGURE 4. An assortment of macrolepidoptera collected from old growth aspen forest near Touchwood Lake, Alberta (ruler = 1 cm).

mon Cattail (*Typha latifolia*), is available. Larvae feed on the flowers and seeds.

Coleotechnites blastivora (McLeod) (Gelechiidae):
Reported only from the type locality of Gaspe, Quebec (McLeod 1962). It probably occurs across the boreal zone.

Larvae are needle webbers of White Spruce, occasionally mining within the needles.

Gnorimoschema septentrionella Fyles (Gelechiidae):
Miller (2000) reports this species only in eastern North America, as far west as Minnesota. It is a stem-gall maker on asters (*Aster* spp.).

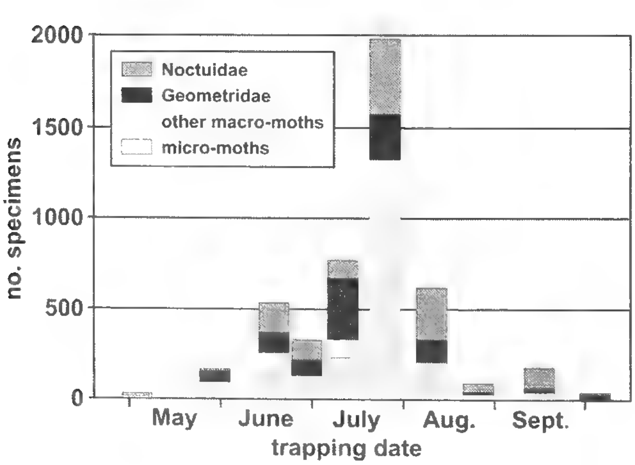

FIGURE 5. Abundance of major Lepidoptera groups collected in UV traps through the 1994 trapping season.

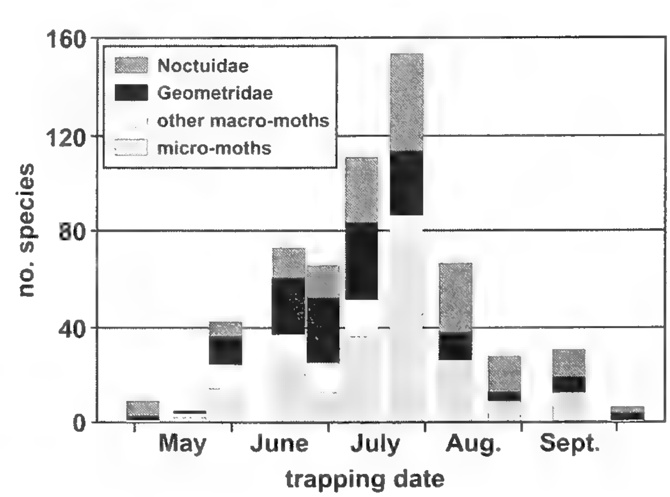

FIGURE 6. Species richness of major Lepidoptera groups collected in UV traps through the 1994 trapping season.

Aethes promptana (Robinson) (Tortricidae – Tortricinae):

The Touchwood Lake record represents the first record of this species from western Canada. It was previously known from eastern North America as far west as Wisconsin (Sabourin et al. 2002). A prevoius record from Washington (Razowski 1997) was based on a misidentification. Nothing is known of it's feeding habits.

Wockia asperipunctella (Bruand) (Urodidae):

As noted by Landry (1998), this Touchwood Lake record represents the first report of this species, and the family Urodidae, in Alberta. This family is a recently recognised addition to the North American fauna (Heppner 1997). Larvae feed on Trembling Aspen; adults tend to fly during the day or early evening.

Alucita lalannei Landry & Landry (Alucitidae):

Until recently, this species had been combined with two other species in the genus, and referred to collectively as *Alucita hexadactyla* (Linnaeus) (Bowman 1951; Hodges et al. 1983; Poole 1996). However, the true *A. hexadactyla* is restricted to the Old World. In their description and treatment of *A. lalannei*, Landry and Landry (2004) designate a specimen from the current study as a paratype. This species is known from Ontario, Manitoba, and Alberta. Adults overwinter, and can be collected from May to September. The larval host plant is unknown, but Landry and Landry (2004) report *Lonicera* spp. and *Symphoricarpos* spp. as likely candidates.

Parapoynx maculalis (Clemens) (Crambidae):

Previously known from eastern North America, only as far west as Lake of the Woods, Ontario (Munroe 1972). However, recent collecting by GRP indicates that it is widespread but extremely localised in Alberta and Saskatchewan. Its larvae are aquatic, and are reported by Munroe (1972) to feed on several species of water lilies (*Nuphar, Nymphaea, Brasenia* spp.). It likely feeds on other plants as well, since it has been collected recently in southern Alberta, outside the distribution of the aforementioned plants (C. D. Bird, personal communication).

Idia new species near *aemula* Hübner (Noctuidae – Herminiinae):

Usually mixed in with *Idia aemula* Hübner in collections. It was reported in eastern North America by Rings et al. (1992), and misidentified as *Epizeuxis concisa* Walker by Forbes (1954). It remains undescribed and has not been reported previously from Alberta, although it is common across the boreal region. It has been reported to feed on the needles of a variety of conifers (Rings et al. 1992).

Phalaenostola hanhami (J. B. Smith) (Noctuidae – Herminiinae):

Reported from eastern Saskatchewan as far west as Regina (Hooper 1988). Nothing is known of its feeding habits.

The only similar published study of boreal forest Lepidoptera that the authors are aware of is that of Morneau (2002), which sampled primarily macro-moths near Peace River in northwestern Alberta. In that study, 293 species were collected over three seasons, including 278 species of macro-moths. Although most macro-moth species were common to both studies, 43 species were unique to the present study, and 115 species were unique to the Morneau study. The presence of so many unique species suggests some habitat specialization within the boreal mixedwood region. Several of the species unique to the Morneau study, most notably some Arctiidae species, represent an incursion of cordilleran species into that area.

Several Lepidoptera inventories of provincial parks in the boreal mixedwood forest of northeastern Alberta have been carried out (Schmidt and Pohl 2001*; Macaulay and Pohl 2002*, 2003*). Although these studies collected from 138 to 295 species, they were each based on brief sampling periods, so they missed significant proportions of the fauna. Catches from the current study shared approximately 50 to 60% of the species collected in those studies.

In general, the moth fauna of the boreal forest appears to be less diverse than that found in other forests. Summerville and Crist (2002) collected 512 species of moths in deciduous forests in Ohio. Thomas et al. (1998) collected 624 species of macro-moths in Fundy National Park, New Brunswick, which lies in the Acadian Forest Region, as described by Rowe (1972). Both of these forest types are more diverse botanically than the boreal forest, and have more moderate climatic conditions (Rowe 1972).

Inventories of this nature are a necessary prerequisite to understand impacts of forestry practices and climate change on biodiversity. However, there is a paucity of similar studies, largely due to the lack of required taxonomic expertise. This argues strongly for increased support of systematics research in Canada, as biodiversity issues continue to increase in importance.

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Pilose Braya, *Braya pilosa* Hooker (Cruciferae; Brassicaceae), an Enigmatic Endemic of Arctic Canada

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Harris, James G. 2004. Pilose Braya, *Braya pilosa* Hooker (Cruciferae; Brassicaceae), an enigmatic endemic of Arctic Canada. Canadian Field-Naturalist 118(4): 550-557.

Braya pilosa Hooker, Pilose Braya, has been poorly understood among North American botanists due to a paucity of fruiting specimens for study. This has resulted in confusion about the taxonomic position of the taxon within *Braya*, and has led to speculation about its generic status. An examination of fruiting specimens from the Royal Botanic Garden Herbarium at Kew, England reveals that *B. pilosa* is correctly placed in the genus *Braya*, and that it is a distinctive member of the genus deserving recognition at the specific level. I discuss the historical evidence that *B. pilosa* may not have been collected since 1850 due to its extremely restricted distribution on the Cape Bathurst Peninsula of the Northwest Territories of Canada. I also present evidence suggesting that *B. pilosa* is diploid and may be a parent species to some of the more widespread members of the genus, all of which are polyploid. Its closest living relative is probably *B. thorild-wulffii*.

Key Words: *Braya pilosa*, Pilose Braya, discovery, rediscovery, distribution, collections, rare species, Cape Bathurst, Northwest Territories, Canada.

Braya pilosa Hooker (Figure 1) is an extremely rare endemic of the Northwest Territories of Canada. It is perhaps the most distinctive and, at the same time, least understood North American member of a taxonomically difficult genus. While some botanists (Harris 1985; Argus and Pryer 1990; Rollins 1993; McJannet et al. 1995) have treated *B. pilosa* as it was envisioned and described by Hooker (1830), most have placed it into synonymy under *B. glabella* (Polunin 1959; Welsh 1974; Porsild and Cody 1980; Cody 2000; Warwick et al. 2000*) or *B. purpurascens* (Scoggan 1978). Others have reduced it to infraspecific status within *B. purpurascens* (Schultz 1924; Hultén 1970), applied the name broadly to elements of *B. glabella* (Porsild 1943, Hultén 1968), or ignored it entirely (Cody 1979; Mulligan 2002). To the best of my knowledge, there are no authentic fruiting specimens of *B. pilosa* in any North American herbarium. It is this lack of available fruiting material for study that is primarily responsible for the taxonomic confusion that has surrounded this taxon over the past 173 years.

When he described the species, Hooker (1830) had only a single collection of flowering individuals with immature silicles from which to work and he was apparently uncertain whether or not the plant was actually a *Braya*. He placed a question mark behind the genus name, lamented the lack of mature fruits that would allow unequivocal generic placement, and stated, "...in all probability, it ought to constitute a new genus." Without access to mature fruits for examination, Hooker's suggestion of a new genus would indeed seem justified. The flowers are larger than those in any other *Braya* species (the petals in some tetraploid *B. humilis* are as long but not as broad); the immature silicles are ovoid-ellipsoid, unlike those in any other *Braya* with the exception of *B. thorild-wulffii* (which had not been discovered in 1830); and the styles are exceptionally long for a *Braya*, measuring over half the length of the ovary. In addition, Sir John Richardson (1830), who collected the type specimen in 1826 during the second Franklin expedition in search of a northwest passage, described the flowers as fragrant, with a smell similar to lilac blossoms. Fragrance has not been associated with any other member of the genus.

Murray (1983*) and Scott et al. (2000*) suggested that *B. pilosa* is a misnomer applied in error by Hooker (1830) to a *Draba*, likely *D. corymbosa*. However, Hooker's original description and accompanying illustration of the taxon indicate that he is describing something quite different from *D. corymbosa*. Hooker describes the valves of the immature silicles as "valde convexis," and again later as "remarkably convex," descriptions that do not accurately describe the distinctly flattened valves of *D. corymbosa*.

Fortunately, any doubt about the identity of Hooker's *B. pilosa* as a legitimate *Braya* rather than as a misidentified *D. corymbosa* is resolved by an examination of authentic fruiting specimens. There is a herbarium sheet at the Royal Botanic Gardens Herbarium (K) in Kew, England (Figure 2) that apparently includes specimens from three separate collections (Sea Coast, Arctic, Richardson *s.n.*, 1848; arctic coast, W. of C. Bathurst, Captn. Pullen *s.n.*, Aug. 1850; and what are likely part of Richardson's type collection of 1826). The herbarium sheet is so congested that it is impossible to be certain which individuals are part of the various collections represented, but all of them are definitely members of the same taxon. Mature silicles on

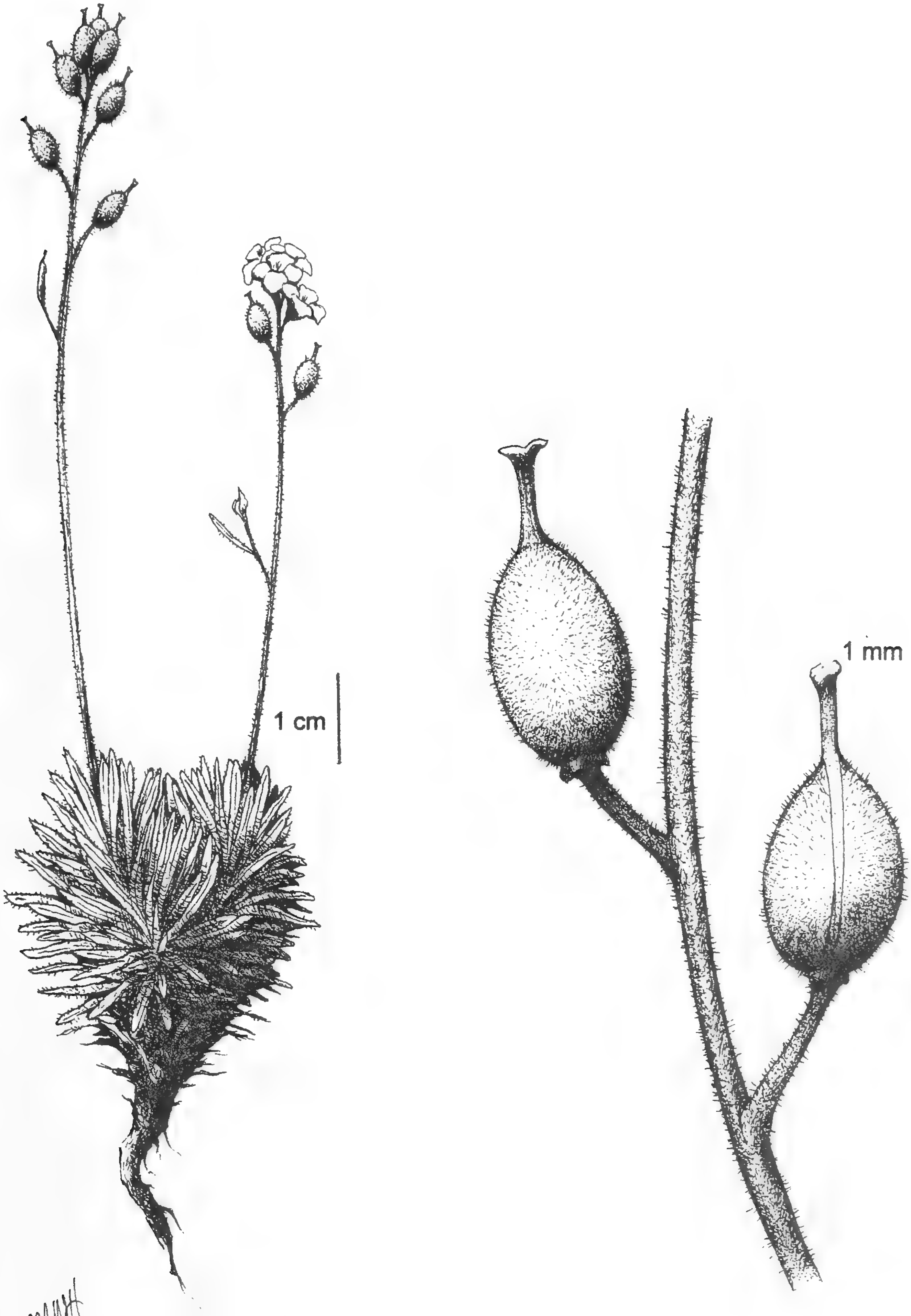

FIGURE 1: Illustration of *Braya pilosa*.

these specimens, even though pressed, are clearly ovoid-ellipsoid and perfectly match Hooker's illustrations of immature fruits of *B. pilosa*. In addition to possessing fruits that are strikingly different from those of *D. corymbosa*, the Kew *B. pilosa* specimens differ significantly from *D. corymbosa* in several other attributes. The leaves are much longer, narrower, thicker, more obtuse, and less densely pubescent than those in *D. corymbosa*; some individuals bear a single cauline leaf while *D. corymbosa* lacks cauline leaves; the styles are much longer than those of *D. corymbosa*; and most importantly, the epidermal cells of the silicle septum are typical *Braya* epidermal cells, characteristically thickened and transversely or obliquely elongated (Harris 1985, Figure 2), in stark contrast to the thin-walled, irregularly shaped, and essentially isodiametric septum epidermal cells typical of *Draba*. *Braya pilosa* is unequivocally *not* a misidentified *Draba*.

I have not seen any authentic specimens of *B. pilosa* that have been collected since 1850. It is possible that it is extinct, as Argus and Pryer (1990) and McJannet et al. (1995) have suggested, but I think it more likely that its distribution is so limited that it has simply been overlooked by botanists. Hooker's (1830) description of the type locality of *B. pilosa*, "Mouth of Mackenzie River, lat. 70°" may be somewhat misleading to those who have looked for *B. pilosa* over the last century or so. Porsild, for example, made several collections of *Braya* between the mouth of the Mackenzie River and Nicholson Island in Liverpool Bay, where Hooker's location description suggests that *B. pilosa* should be found. Although Porsild initially identified his collections as *B. pilosa* (Porsild 1943), none of them show the distinctive ovoid-ellipsoid silicles, exceptionally long styles, and large flowers of this taxon and fall instead within the normal range of diversity in *B. glabella*.

There is evidence that Hooker's description of the type locality may be his interpretation of Richardson's broad conception of the Mackenzie Delta rather than a precise description of Richardson's collection location. In his account of the 1826 journey from the Mackenzie River to Cape Bathurst, Richardson (1828) repeatedly commented on the alluvial deposits and sandbars his party encountered in the area, and correctly attributed them to outwash from the Mackenzie. He clearly viewed the entire region of the Tuktoyaktuk Peninsula, Eskimo Lakes, and Liverpool Bay as a product of a historical Mackenzie Delta. It is likely, however, that Richardson was actually very near Cape Bathurst rather than the mouth of the Mackenzie when he collected the type specimens of *B. pilosa*. In fact, there is some evidence that all three known collections of *B. pilosa* (Richardson in 1826 and 1848; Pullen in 1850) may have come from the same stretch of seashore near Cape Bathurst, roughly 200 km northeast of the mouth of the Mackenzie River.

John Richardson's original collection of *B. pilosa* almost certainly occurred on 18 July 1826, as the eastern detachment of Franklin's second expedition in search of a northwest passage was approaching Cape Bathurst. This eastern detachment, under Richardson's command, was assigned the task of exploring the arctic sea coast by boat from the Mackenzie River east to the Coppermine River, then traveling overland on foot from the Coppermine River to Great Bear Lake. On 18 July, Richardson (1828) records stopping for breakfast "about eight miles" from the narrow passage between Cape Bathurst and the Baillie Islands. He writes, "The air was perfumed by numerous tufts of a beautiful phlox, and of a still handsomer and very fragrant cruciform flower, of a genus hitherto undescribed." There is little doubt that the "cruciform" flower Richardson is describing is *B. pilosa*. First, 18 July is a date that an arctic *Braya* would be expected to be in a flowering rather than a fruiting condition. In addition, the dense clusters of large flowers on his type specimens would certainly be "handsome," and Richardson's description of the plant's fragrance and uncertain generic status matches perfectly with Hooker's (1830). No other cruciferous species included in Hooker's *Flora Boreali-Americana*, which treats all of Richardson's collections from this expedition, fits Richardson's 18 July plant description as well as *B. pilosa*.

Richardson collected *B. pilosa* a second time in 1848, this time when the plant was in fruit. Captain Sir John Franklin, along with his ships, the Erebus and Terror, and their crews disappeared in the Canadian Arctic in 1845. Franklin's ships carried sufficient provisions to last until the summer of 1848, but by 1847, when nothing had been heard from Franklin, the British Admiralty began mounting search expeditions. In 1848, John Rae and John Richardson were placed in command of one of these search parties. Richardson's orders were to search the arctic coast and islands east of the Mackenzie River to the Coppermine River and then travel overland from the Coppermine to Great Bear Lake, essentially retracing his 1826 journey. Unfortunately, Richardson did not mention his 1848 collection of *B. pilosa* in his published account. However, I think it is likely that this second collection was made at exactly the same place as the first. On 10 August, Richardson was approaching Cape Bathurst again, twenty-two years after his first visit there (Richardson 1851). This is exactly the right season to find *Braya* in fruit. Given Hooker's uncertainty about the generic status of *B. pilosa* due to a lack of fruiting material for examination, it is inconceivable that Richardson would not have taken the opportunity to revisit his original collection location to collect fruiting plants which would allow a definitive identification.

Braya pilosa was collected for a third and apparently last time in August of 1850 from the "arctic coast, W. of C. Bathurst" by Captain William J. S. Pullen. In 1850, Pullen, also in command of an expedition in search of Franklin, attempted to travel from Fort Simpson on the Mackenzie River to Cape Bathurst and then on to Banks Island. In mid-August he was in the vicin-

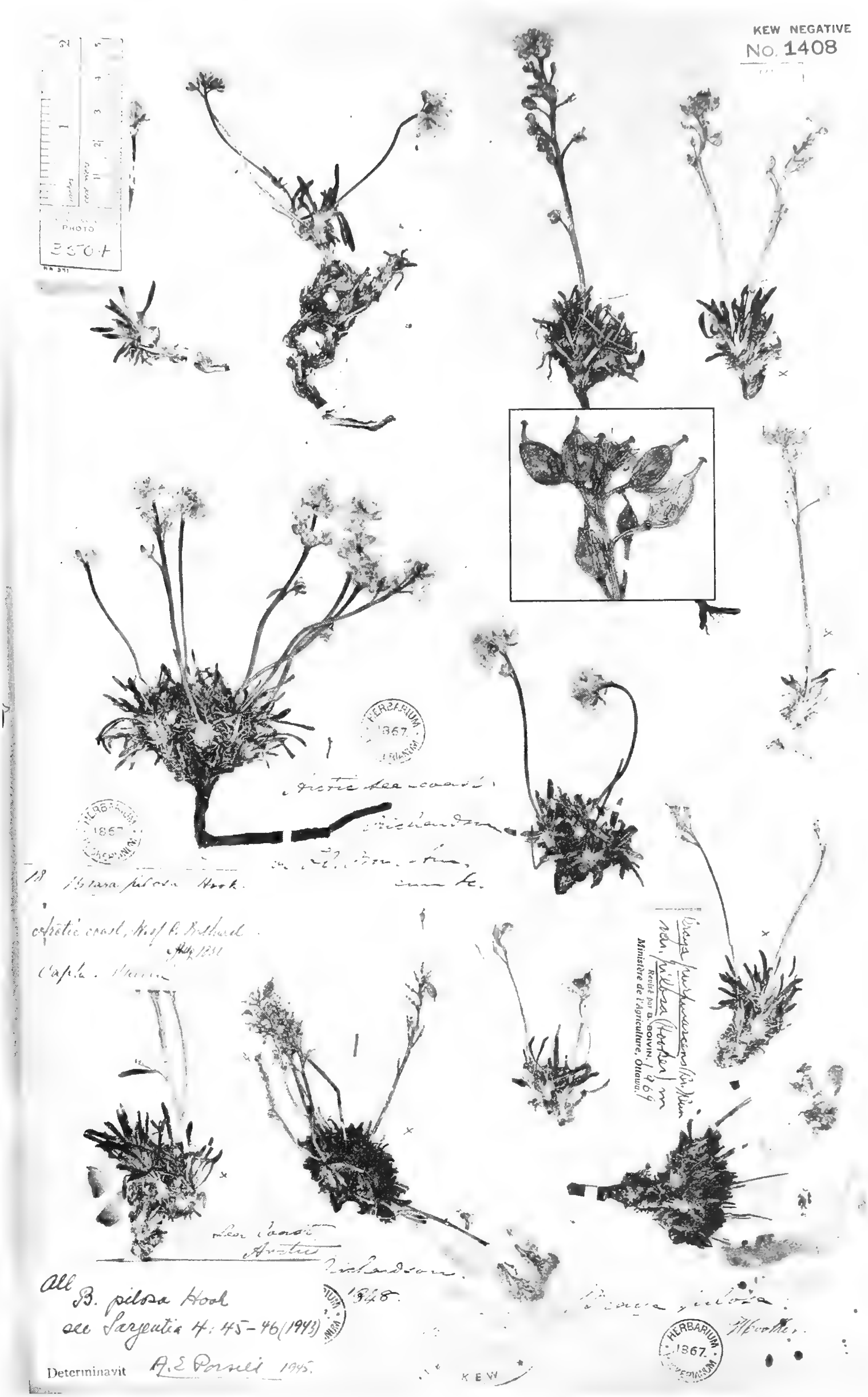

FIGURE 2: Photograph of mixed collections of *Braya pilosa* on a herbarium sheet at the Royal Botanic Gardens Herbarium (K) in Kew, England. Insert is an enlarged view of mature silicles.

FIGURE 3: Map of Cape Bathurst Peninsula, Northwest Territories, Canada. The dashed box indicates the probable type locality of *Braya pilosa*.

ity of Cape Bathurst, but found dramatically different ice conditions there than Richardson had two years previously. The pack ice was still so thick that he was unable to proceed past Cape Bathurst, and was forced to retreat back to Fort Simpson. On 8 August, Pullen (1979) recorded that his party "landed in a small bay about 7 miles from Cape Bathurst" to eat dinner. They returned to the same bay about midnight on 10 August, after having been turned back by the pack ice at Cape Bathurst, and remained camped there until 15 August while they waited to see if ice conditions at the Cape might improve. This places Pullen within one nautical mile of Richardson's (1828) estimate of his position when I believe he made his first collection of *B. pilosa*, and at the perfect season to find the plant in fruit. He describes the small bay as being "the only place where we could conveniently land," which suggests that it is likely the same place Richardson had chosen to land for breakfast in 1826 when he discovered the plant. In addition, Pullen's steersman was Neil McLeod, a Hudson's Bay Company employee who had also accompanied Richardson in 1848. It is probable that McLeod would have mentioned Richardson's interest in the plant to Pullen and perhaps inspired him to make his own collection during the four days they were camped at the site.

If Richardson's and Pullen's *B. pilosa* collections did come from the same location on Cape Bathurst Peninsula, the position of that location would most likely be between about 70° 27' and 70° 28' north latitude along the western coast of the peninsula (Figure 3). Or perhaps slightly farther north if their estimates of the distance to Cape Bathurst were based on the distance they actually traveled along the coastline rather than the direct straight-line distance. This section of coastline should be searched carefully for extant populations of *B. pilosa*.

While the rediscovery of *B. pilosa* would of itself be interesting botanically and historically, the availability of living plants for study would also be tremendously valuable to our understanding of *Braya*. The evolution of the genus is intimately tied to hybridization and polyploidy (Harris 1985), but that phylogenetic history is obscured by the fact that diploidy has never been reported in *Braya*. There is some evidence, however, that *B. pilosa* may be diploid and, therefore, could have played a critical role in the evolutionary history of *Braya*. Ornduff (1969) listed several attributes in flowering plants that are correlated with xenogamy and a diploid chromosome number. Among them are rotate corollas with large petals, exserted styles, scented flowers, abortive fruits, and a narrow distribution. *Braya pilosa* has the largest petals and longest styles of any *Braya*, it is the only species in the genus with scented flowers, it appears to have a fairly high frequency of abortive silicles, and it has a very narrow

FIGURE 4: Photograph of *Braya pilosa* specimen collected on 24 July 2004 (J. G. Harris and D. L. Taylor 3644).

distribution. Large, rotate flowers, allogamy, abortive fruits, and narrow distributions also have been associated with lower ploidy levels in *B. humilis* (Harris 1985), though these are tetraploids rather than diploids.

Pollen measurements also provide evidence that *B. pilosa* may be diploid. Rollins (1953) and Böcher (1956) noted a correlation of ploidy level and pollen size in *B. humilis*, with populations of lower ploidy level having somewhat smaller pollen grains than those of higher ploidy level. Pollen sizes in *B. pilosa*, *B. thorild-wulffii*, and *B. glabella* show a similar correlation. Measurements (Harris 1985) indicate that *B. pilosa* has significantly smaller pollen grains than the tetraploid *B. thorild-wulffii*, with the largest pollen grains being found in the octoploid *B. glabella*.

If *B. pilosa* is indeed diploid, its extremely limited distribution may be linked to its ploidy level. Favarger (1961) and Johnson and Packer (1967) found a correlation between plant ploidy level and habitat stability. Diploids were more likely to be found on stable habitats, while polyploids were more frequent on habitats with a history of disturbance. Areas that remained unglaciated during the Pleistocene, for example, were found to have a significantly higher percentage of diploids in their floras than areas that were glaciated (Favarger 1961; Johnson and Packer 1967). The Cape Bathurst Peninsula is known to have been unglaciated during the Pleistocene (Prest 1969) and probably served as a refugium for plants that moved back onto their former ranges as the ice receded. *Braya pilosa* likely weathered the Pleistocene on the relatively stable habitats available near Cape Bathurst, but it has apparently been unable to expand its range in recent times. It may, however, have served as a parent species to some of the more widespread polyploids in the genus. A likely candidate is *B. thorild-wulffii*, a high arctic North American endemic that shares *B. pilosa's* ovoid-ellipsoid fruit shape and fenestrate silicle septae, and appears to be most closely related to it. *Braya thorild-wulffii* is a tetraploid (2n=28) (Holmen 1952; Mulligan 1965, 2002; Böcher 1966; Harris 1985), which is the lowest reported ploidy level in the genus (some populations of *B. humilis* are also tetraploid). However, Böcher (1966) observed that there appears to be only a single large pair of chromosomes in *B. thorild-wulffii*, so it is probably not simply an autotetraploid from a single diploid parent.

DNA sequence data (Harris, unpublished data) suggest that *B. thorild-wulffii* may have served as a parent to other *Braya* species of higher ploidy level. If DNA of *B. pilosa* were available, and if the species is indeed a parent to *B. thorild-wulffii*, it could provide significant insight into phylogenetic relationships within *Braya* and between *Braya* and other genera in the Cruciferae.

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Addendum

On 24 July 2004, Daniel L. Taylor and I briefly visited Richardson's presumed type locality of *Braya pilosa* near Cape Bathurst. We discovered several hundred *B. pilosa* individuals growing along the coastline on sandy, calcareous soils in an area heavily used by Caribou (*Ranifer taranclus*). The plants were limited to small, bare patches of soil disturbed by Caribou hoofs.

The plants on Cape Bathurst Peninsula (Figure 4) are perfect matches for Richardson's and Pullen's 19th Century *B. pilosa* collections (Figure 2). Specimens (J. G. Harris and D. L. Taylor 3644) are deposited in the Utah Valley State College Herbarium (UVSC), with duplicate material distributed to the following herbaria: Agriculture and Agri-Food Canada (DAO), Canadian Museum of Nature (CAN), Missouri Botanical Garden (MO), New York Botanical Garden (NY). DNA sequencing and cytological studies are currently underway (Harris, unpublished data).

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New Records of Vascular Plants in the Yukon Territory VI

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Based on field reconnaissance mainly in 2002 in the southern part of the Yukon and particularly in and adjacent to Kluane National Park, information is provided on geographically significant plant occurrences. Six native taxa, *Atriplex alaskensis*, *Claytonia megarrhiza*, *Corispermum ochotense* var. *alaskanum*, *Oxytropis arctica*, *Polemonium acutiflorum* forma *lacteum* and *Polemonium boreale* forma *albiflorum*, and four introduced taxa, *Arabis caucasica*, *Camelina sativa*, *Senecio eremophilus*, and *Setaria viridis* are reported new to the known flora of the Yukon Territory. Significant range extensions for 158 native and 21 introduced taxa are included. *Parrya arctica*, *Armoracia rusticana*, *Atriplex patula* and *Papaver nudicaule* ssp. *nudicaule* are excluded from the Yukon flora.

Key Words: Vascular plants, Yukon Territory, flora, new records, range extensions, phytogeography.

Since the writing of *New Records of Vascular Plants in the Yukon Territory V* (Cody et al. 2003), a considerable number of plant specimens have been submitted to Cody for identification and confirmation. The major submissions include the following locations and collectors: (1) Kluane National Park and vicinity by Phil Caswell for the National Park Service as part of ongoing botanical inventories; (2) W. J. Cody and Catherine Kennedy spent four days collecting specimens in the Fort Selkirk area assessing the flora of that region; (3) W. J. Cody and Margaret Cody studied changed vegetation along the southern highways; (4) Bruce Bennett conducted studies adjacent to the North Canol Road, assisting with rare plant surveys for Yukon-Charley Rivers National Park and interesting areas while boating down the Yukon River; (5) Rhonda Rosie visited sites adjacent to Nisling Lake and Morris Lake for the Yukon Territory Government and Parks Branch; (6) Stu Withers visited former mine sites at Atlin Lake and Deadman Creek in connection with reclamation of vegetation and soil stabilization; (7) with his continuing interest in vegetation habitats Greg Brunner collected plant specimens from areas adjacent to the Klondike River and Dawson City.

This paper serves to further update the *Flora of the Yukon Territory* (Cody 1996) and *Flora of the Yukon Territory, Second Edition* (Cody 2000) along with other records recently published (Cody et al. 1998, 2000, 2001, 2002, 2003). The floristic information presented earlier and updated here is essential for biological research and ongoing work relating to agriculture, forestry, sustainable resource management and wildlife management. With additions of six native and four introduced species reported here, the flora now includes 1181 species. The new native species are all rare (as defined by Douglas et al. 1981).

The taxa addressed in the body of this paper appear in a synoptic list by Yukon status in alphabetical order. The taxa are then discussed in taxonomic order, as presented in the *Flora of the Yukon Territory* with citation of specimens and other pertinent information. Common names follow Cody (1996) and Douglas et al. (1998-2001).

Synoptic List by Yukon Status

Errata in New Records: (5)

Carex stylosa
Douglasia arctica
Poa nemoralis revised to *Poa interior*
Armoracia rusticana revised to *Rorippa barbareifolia*
Papaver nudicaule ssp. *nudicaule* revised to *Papaver croceum*

Native Taxa New to the Yukon Territory: (6)

Atriplex alaskensis
Claytonia megarrhiza
Corispermum ochotense var. *alaskanum*
Oxytropis arctica
Polemonium acutiflorum forma *lacteum*
Polemonium boreale forma *albiflorum*

Introduced Taxa New to the Yukon Territory: (4)

Arabis caucasica
Camelina sativa
Senecio eremophilus
Setaria viridis

Range Extensions of Native Taxa within the Yukon Territory: (158)

Agrostis filiculmis
Allium schoenoprasum ssp. *sibiricum*
Alyssum obovatum
Amelanchier alnifolia
Arabis holboellii var. *retrofracta*
Arabis holboellii var. *secunda*
Aster alpinus ssp. *vierhapperi*
Aster falcatus

Atriplex subspicata
Bromus ciliatus
Callitriche anceps
Cardamine bellidifolia
Carex albo-nigra
Carex athrostachya
Carex atrosquama
Carex capillaris ssp. *chlorostachys*
Carex crawfordii
Carex eleusinoides
Carex foenea
Carex limosa
Carex loliacea
Carex obtusata
Carex pachystachya
Carex pellita
Carex petasata
Carex praegracilis
Carex rossii
Carex supina ssp. *spaniocarpa*
Carex sychnocephala
Carex viridula
Cassiope tetragona ssp. *saximontana*
Cerastium arvense
Chamaerhodos erecta ssp. *nuttallii*
Chenopodium capitatum
Cicuta maculata var. *angustifolia*
Cryptogramma crispa var. *acrostichoides*
Deschampsia brevifolia
Descurainia incisa var. *incisa*
Douglasia alaskana
Draba aurea
Draba corymbosa
Draba crassifolia
Draba glabella
Draba nemorosa
Draba ogilviensis
Draba palanderiana
Draba porsildii
Draba stenoloba
Dryas hookeriana
Eleocharis uniglumis
Elymus alaskanus ssp. *alaskanus*
Elymus glaucus
Elymus macrourus
Elymus spicatus
Elymus trachycaulus ssp. *andinus*
Erigeron caespitosus
Erigeron hyperboreus
Eriophorum brachyantherum
Eritrichium aretioides
Eritrichium chamissonis
Euphrasia subarctica
Festuca brachyphylla
Festuca richardsonii
Festuca saximontana
Gentianella tenella
Geum aleppicum ssp. *strictum*
Geum rossii
Glyceria striata var. *stricta*
Gymnocarpium jessoense ssp. *parvulum*
Harrimanella stellariana
Hordeum brachyantherum
Iris setosa ssp. *interior*
Isoetes echinospora
Isoetes ?maritima
Juncus bufonius
Juncus filiformis
Kobresia simpliciuscula
Koeleria macrantha
Lepidium densiflorum var. *densiflorum*
Lupinus nootkatensis
Luzula arcuata ssp. *unalaschkensis*
Maianthemum canadense ssp. *interius*
Mertensia paniculata var. *alaskana*
Mimulus guttatus
Minuartia dawsonensis
Minuartia elegans
Minuartia macrocarpa
Minuartia yukonensis
Montia fontana
Myriophyllum verticillatum
Nuphar polysepalum
Orobanche fasciculata
Oxytropis campestris ssp. *varians*
Pedicularis oederi
Phacelia mollis
Phlox hoodii
Phyllodoce glanduliflora
Pinguicula villosa
Pinus contorta ssp. *latifolia*
Plantago canescens
Plantago maritima
Poa interior
Poa leptocoma
Poa secunda
Podistera macounii
Polygonum lapathifolium
Potamogeton alpinus ssp. *tenuifolius*
Potamogeton berchtoldii
Potamogeton gramineus
Potamogeton pectinatus
Potamogeton praelongus
Potamogeton subsibiricus
Potamogeton zosteriformis
Potentilla arguta var. *convallaria*
Primula eximia
Puccinellia interior
Pulsatilla ludoviciana
Pyrola minor
Ranunculus aquatilis var. *subrigidus*
Ranunculus occidentalis var. *brevistylis*
Rhinanathus minor ssp. *borealis*
Ribes oxyacanthoides ssp. *oxyacanthoides*
Rorippa barbareifolia
Rosa woodsii
Salix alaxensis ssp. *longistylis*
Salix glauca var. *acutifolia*
Salix pseudomyrsinites
Salix rotundifolia ssp. *dodgeana*
Sambucus racemosa ssp. *pubens*
Saxifraga caespitosa
Saxifraga eschscholtzii
Saxifraga foliolosa
Saxifraga nelsoniana ssp. *pacifica*
Saxifraga rufopilosa
Saxifraga tricuspidata
Scirpus rollandii
Silene involucrata ssp. *tenella*
Silene williamsii

Solidago canadensis var. *salebrosa*
Spiranthes romanzoffiana
Stellaria umbellata
Stipa comata
Stipa nelsonii ssp. *dorei*
Stipa richardsonii
Subularia aquatica ssp. *americana*
Tofieldia coccinea
Trientalis europaea
Triglochin palustre
Typha latifolia
Urtica dioica ssp. *gracilis*
Utricularia minor
Vaccinium membranaceum
Vahlodea atropurpurea
Valeriana sitchensis
Vicia americana
Viola renifolia var. *brainerdii*
Woodsia alpina
Woodsia ilvensis

Range Extensions of Introduced Taxa within the Yukon Territory: (21)
Agropyron pectiniforme
Agropyron sibiricum
Agrostis gigantea
Avena sativa
Brassica rapa
Bromus inermis
Capsella bursa-pastoris
Elytrigia intermedia
Galeopsis tetrahit ssp. *bifida*
Lepidium densiflorum var. *macrocarpum*
Myosotis scorpioides
Papaver croceum
Poa annua
Rheum rhabarbarum
Rumex crispus
Silene vulgaris
Sinapis arvensis
Sonchus arvensis ssp. *uliginosus*
Tanacetum vulgare
Thlaspi arvense
Trifolium pratense

Comments on Native Taxa in the Yukon Flora: (3)
Carex stylosa
Douglasia arctica
Isoetes ?maritima

Deletions of Native Taxa from the Yukon Flora: (1)
Parrya arctica

Deletions of Introduced Taxa from the Yukon Flora: (3)
Armoracia rusticana
Atriplex patula
Papaver nudicaule ssp. *nudicaule*

Annotated Species List

ISOETACEAE

Isoetes echinospora Dur., Bristle-like Quillwort – YUKON: On stony shore of small pond south of Morris Lake, 60°20'N 131°40'W, *R. Rosie 2030*, 8 Sept. 1999 (DAO); washed up on lakeshore, northeast shore of Nisling Lake, 62°02'00"N 137°58'30"W, *R. Rosie 02-821*, 12 Aug. 2002 (DAO) (determined by D. F. Brunton).

The first specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 180 kilometers southwest of the vicinity of Francis Lake. The second specimen is from a site about 500 kilometers northwest of Frances Lake and about 430 kilometers northwest of the Morris Lake site.

Isoetes ?maritima Underw., Maritime Quillwort – YUKON: washed ashore, WNW side of Trout Lake, 68°49'27"N 138°45'8"W, *J. M. Line 2000-72*, 28 July 2000 (DAO) (determined by D. F. Brunton & D. M. Britton).

The fragmented specimens found washed up along the shore of the lake possessed only immature female spores which were mostly densely tuberculate but could not definitely be determined as *I. maritima*. If this could be verified by more mature specimens from Trout Lake it would be only the third known location in the Territory and a range extension of about 260 kilometers northwest of Vittrewka Lake (Cody et al. 2001).

Isoetes maritima Underw., Maritime Quillwort – It has been brought to our attention by Lori Schroeder (Environment Yukon) that specimen data according to Greg Brunner's field notebook for his collection #39-99 which was published in Cody et al. (2001) should be: Peel River Wetland Study Turner Lake, 66°11'N 134°14'W, 2 July 1999.

PTERIDACEAE

Cryptogramma crispa (L.) R. Br. var. *acrostichoides* (R. Br.) C. B. Clarke, Mountain-parsley – YUKON: Kluane National Park, south-facing scree slope, 60°06.019'N 137°08.532'W, *P. Caswell 026*, 6 June 2002 (DAO).

This rare species which was previously known from only six localities in the Territory is now known from two sites in southern Kluane National Park.

ASPIDIACEAE

Gymnocarpium jessoense (Koidz.) Koidz. ssp. *parvulum* Sarvela, Nahanni Oak Fern – YUKON: dry rock outcrop, lower Beaver River, 60°09'09"N 124°55'16"W, *B. Bennett 97-518*, 19 Aug. 1997 (B. Bennett Herbarium, photo DAO).

The specimen cited above of this rare plant in the Territory is an extension of the known range of about 300 kilometers from a site in the vicinity of Francis Lake (Cody 1996).

Woodsia alpina (Bolton) S. F. Gray, Northern Woodsia – YUKON: damp organic soil in rock crevice, Cache Lake, Kluane National Park, 61°12.586'N 139°03.671'W, *P. Caswell 575*, 24 July 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 45 kilometers southwest of a site at the north end of Kluane Lake and is new to the flora of Kluane National Park.

Woodsia ilvensis (L.) R. Br., Rusty Woodsia – YUKON: steep south-facing bluffs along Klondike River, Dawson Area, 1 mile north of 64°02'N 137°41'30"W, *G. Brunner 435*, 2 June 2001 (DAO); dry rocky outcrop,

S Fork bluffs, Klondike River, 64°01'N 138°9'W, *G. Brunner 443-01*, 14 July 2001 (DAO).

Douglas et al. (1981) considered this species rare in the Territory. The specimens cited above are from sites about 60 kilometers southwest of a site adjacent to the Dempster Highway mapped by Cody (1996).

PINACEAE

Pinus contorta Dougl. ex Loud. ssp. *latifolia* Engelm. ex S. Wats., Lodgepole Pine – YUKON: roadside, North Canol Road KM 284, 62°13'02"N 131°46'10"W, *B. Bennett 02-723*, 22 Sept. 2002 (DAO); roadside across road from large truck dump, North Canol Road Km 380, 62°50'03"N 130°56'24"W, *B. Bennett 02-724*, 21 Sept. 2002 (DAO).

The specimens cited above are an extension of the known range in the Territory of about 175 kilometers northeast of a site adjacent to the South Canol Road. The second specimen was from a site adjacent to an old house and may have been planted.

TYPHACEAE

Typha latifolia L., Common Cattail – YUKON: border of small lake below swimming pool, Takhini Hot Spring, 60°52'40.7"N 135°21'30.6"W, *Cody & Cody 37692*, 10 Aug. 2001 (DAO); same locality (fruiting) *Cody 38311*, 4 Aug. 2002 (DAO).

Douglas et al. (1981) considered this species rare in the Territory. Cody (1996) knew it only from the vicinity of Mayo. Cody et al. (2000, 2001) added additional sites in the extreme southeast and in the vicinity of Faro. The specimen cited above which was collected just west of Whitehorse is now from the fourth site in the Territory.

POTAMOGETONACEAE

Potamogeton alpinus Balbis ssp. *tenuifolius* (Raf.) Hultén – YUKON: plant fragments washed ashore, Trout Lake, 68°50'N 138°45'W, *J. M. Line 2000-9*, 29 July 2000 (DAO).

The specimen cited above is the northernmost yet found in the Territory. It is an extension of the known range (Cody 1996) of about 85 kilometers NE of a site north of latitude 68°N.

Potamogeton berchtoldii Fieb. – YUKON: shallow water of small lake, west side of Dempster Highway Km 93, 64°39'01"N 138°23'01"W, *Cody & Cody 38060*, 27 July 2002 (DAO).

The specimen cited above is from a site about 80 kilometers northeast of Dawson City. To the north a single site was previously known from adjacent to the Peel River (Cody 1996).

Potamogeton gramineus L., Variable-leaved Pondweed – YUKON: slough off Yukon River with old sunken dredge, 61°56'35"N 135°12'17"W, *B. Bennett 02-299*, 7 Aug. 2002 (DAO).

The nearest site to that listed above known to Cody (1996) is about 75 kilometers to the north.

Potamogeton pectinatus L., Sago Pondweed – YUKON: shallow backwater, Dezadeash River, Kluane National Park, 60°45.683'N 137°36.010'W, *P. Caswell 805*, 16 Aug. 2002 (DAO); locally common in mucky alkaline pond, Mile 985 Alaska Highway, 60°48'N 136°45'W, *Calder & Kukkonen 28277*, 14 Aug. 1960 (DAO).

The specimens cited above extend the known range in the Territory about 120 kilometers west of the vicinity of Whitehorse. The Caswell specimen is the first known from Kluane National Park.

Potamogeton praelongus Wulf., White-stemmed Pondweed – YUKON: Enoch Lake, Old Crow Flats, 68°05'00"N 140°09'50"W, *B. Bennett 95-413*, 10 Aug. 1995 (B. Bennett Herbarium, photo DAO); plant fragments washed ashore, Trout Lake, 68°50'N 138°45'W, *J. M. Line 2000-140*, 28 July 2000 (DAO); Nordenskiold River wetland pond, *M. Dennington*, Nord #23, 19 July 1984 (B. Bennett Herbarium, photo DAO).

Douglas et al. (1981) considered this species rare in the Yukon Territory based on specimens from only two locations. Cody (1996) knew it from five locations. Cody et al. (2000) added three locations. The first specimen cited above is a northwestward extension of about 40 kilometers from the vicinity of Old Crow. The second specimen from about 115 kilometers NNE of Old Crow is the northernmost yet found in the Territory. The third specimen is an extension of the known range in the south of about 125 kilometers northwest of a site just north of Whitehorse.

Potamogeton subsibiricus Hagstr. – YUKON: growing in about 3 feet of water, lake west of Dempster Rd. near mile 65, *R. T. Porsild 317*, 25 July 1966 (AKA, photo DAO) (determined by A. Batten).

Cody (1996) knew this rare species in the Territory from a single collection from adjacent to the North Canol Road about 450 kilometers to the southeast of the locality cited above.

Potamogeton zosteriformis Fern., Flatstemmed Pondweed – YUKON: in water by outlet of pond, Pumphouse Pond, 3 km S of Alaska Highway, 60°43'31.3"N 135°09'58.3"W, *W. J. Cody 38290*, 3 Aug. 2002 (DAO).

Cody (1996) knew this rare species in the Territory from only two localities, one southeast of Haines Junction and one just north of 64°N. Cody et al. (1998, 2000 and 2001) added two sites in the south and one north of 68°N.

SCHEUCHZERIACEAE

Triglochin palustre L., Marsh Arrow-grass – YUKON: silty river bank with *Carex utriculata*, *C. aquatilis* and *Juncus alpinoarticulatus*, Selwyn, Yukon River, 62°48'06"N 138°15'29"W, *B. Bennett 02-294*, 9 Aug. 2002 (DAO).

The specimen cited above is between sites adjacent to the Alaska Highway, Klondike Highway and Dawson City.

POACEAE (GRAMINEAE)

Agropyron pectiniforme R. & S., Crested Wheat Grass – YUKON: lake shore, Earn Lake, 62°.9'08.3"N 134°23'07.6"W, *G. Brunner 557-01*, 5 Aug. 2001 (DAO); steep stony slope on east side of highway, Haines Highway, 60°6'3.2"N 136°54'51"W, *Cody & Cody 37911*, 21 July 2002 (DAO).

The first specimen of this introduced species cited above is from a site between the northernmost mapped by Cody (1996) in the vicinity of Mayo and a site adjacent to Faro. The second specimen cited above is an extension of the known range in the Territory of about 85 kilometers southeast of a site in the vicinity of Haines Junction.

Agropyron sibiricum (Willd.) P. Beauv. – YUKON: top of bank overlooking road into gravel pit south of Alaska Highway, 60°49'58"N 135°45'49"W, *Cody & Cody 38210*, 1 Aug. 2002 (DAO).

Cody (1996) knew this introduced species in the Territory only from two locations, Whitehorse and Carmacks. A third site was reported from the vicinity of Ross River (Cody et al. 2003). The specimen cited above is from a site about 40 kilometers west of Whitehorse.

Agrostis filiculmis M. E. Jones – YUKON: open area – abandoned placer mine, Mechanic Creek, 62°20.1'N 137°21.5'W, *S. Withers SW01-062*, 6 July 2001 (DAO).

The specimen cited above is only the second known in the Territory (Cody 1996) and is from a site about 200 kilometers southeast of the first site in the vicinity of Dawson City.

Agrostis gigantea Roth., Creeping Bent Grass – YUKON: Spruce Hill Park, border of playground at head of Engelman Drive, Whitehorse, 60°36'40.3"N 134°55'08.8"W, *W. J. Cody 37743*, 14 July 2002 (DAO).

Cody (1996) knew this introduced species in the Territory from only two localities, Dawson City and Carmacks. An additional collection from a mine site east of Dawson City was reported by Cody et al. (2003). The specimen cited above is from only the fourth known locality in the Territory.

Avena sativa L., Oats – YUKON: scattered in grass area around Beringia Museum, Whitehorse, 60°42'36"N 135°4'45"W, *Cody & Cody 38105*, 30 July 2002 (DAO).

Cody (1996) knew this introduced species from only widely separated sites in the Territory, vicinity of Mayo, middle of North Canol Road and east of Watson Lake.

Bromus ciliatus L. – YUKON: in moist moss on mountain slope above treeline on east side of Dempster Highway about 9 kilometers north of Tombstone Park Campsite, 64°34'49"N 138°15'30"W, *Cody & Cody 38047*, 26 July 2002 (DAO).

The specimen cited above is at the northern limit of this species in the Territory (Cody 1996). The nearest sites previously mapped were about 120 kilometers to the west adjacent to the Yukon River and about 150 kilometers to the southeast in the vicinity of Stewart Crossing. This species was considered rare in the Territory by Douglas et al. (1981).

Bromus inermis Leyss., Smooth Brome – YUKON: sand beach, Kusawa Lake Campground, 60°5'10"N 136°8'42"W, *Cody & Cody 38144*, 31 July 2002 (DAO); gravel ditch between road and steep gravel slope, Haines Highway, 60°6'3.3"N 136°54'51"W, *Cody & Cody 37912*, 21 July 2002 (DAO).

The specimens cited above of this introduced species which are from sites about 100 kilometers southeast of Haines Junction and southwest of Whitehorse, are the most southwestern yet found in the Territory.

Deschampsia brevifolia R. Br. – YUKON: flats 7 miles east of Tagish Bridge, 60°19'5"N 134°10'17"W, *Cody & Cody 37940*, 23 July 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 90 kilometers southeast of a site west of Whitehorse.

Elymus alaskanus (Scribn. & Merr.) A. Löve ssp. *alaskanus* – YUKON: in sandy soil of river bank, Nisutlin River Delta National Wildlife Area, 60°11'N 132°35'W, *B. Bennett 98-167*, 26 July 1998 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 180 kilometers south of a site adjacent to the northern South Canol Road.

Elymus glaucus Buckl., Western Rye Grass – YUKON: roadstop in disturbed gravelly soil, Atlin Road just north of BC border, 60°00'09"N 133°47'42.1"W, *Cody & Cody 37547*, 28 July 2001 (DAO)

Douglas et al. (1981) considered this species rare in the Territory. The specimen cited above is an extension of about 115 kilometers southeast of a site adjacent to Whitehorse reported by Cody et al. (2002).

Elymus macrourus (Turcz.) Tzvelev – YUKON: growing in loose sand on riverbar, Wind River, camp #6, 65°40.46'N 135°11.76'W, *B. Bennett 00-853*, 7 July 2000 (B. Bennett Herbarium, photo DAO); exposed sandy lakeshore, north end of Atlin Lake, 60°01.5'N 133°50.4'W, *S. Withers SW01-045*, 30 June 2001 (DAO).

The first specimen of this Amphi-Beringian species cited above is the first known from between latitudes 64°N and 66°N east of the Dempster Highway. The second specimen is an extension of the known range in the Territory of about 200 kilometers southwest of a site east of Haines Junction.

Elymus spicatus (Pursh) Gould – YUKON: common at base of large talus slope, Yukon River, Brittania Creek, 62°52'28"N 138°42'56"W, *B. Bennett 02-641*, 10 Aug. 2002 (DAO).

Cody (1996) knew this species in the southwest of the Territory and disjunct to the extreme northwest. The specimen cited above is an extension of the known range in the Territory of about 85 kilometers west of longitude 137°W.

Elymus trachycaulus (Link) Gould ex Shinners ssp. *andinus* (Scribn. & Smith) A. & D. Löve – YUKON: gravel roadside, Top of the World Highway Km 16, 64°6'6"N 139°38'41"W, *Cody & Cody 38035, 38037*, 26 July 2002 (DAO); gravel roadside, Top of the World Highway Km 102, 64°05'33"N 140°55'22"W, *Cody & Cody 38003*, 26 July 2002 (DAO).

The specimens cited above extend the known range in the Territory to the west about 140 kilometers from a site east of the Dempster Highway.

Festuca brachyphylla Schultes & Schultes f., Shortleaf Fescue – YUKON: Site KPL #106, 62°17'38.7"N 137°48'25"W, *G. Brunner 578-01*, July 2001 (DAO).

The specimen cited above is from a site between sites mapped by Cody (1996) west of Carmacks and adjacent to southern Dempster Highway.

Festuca richardsonii Hooker – YUKON: beside test plot, 1 km N of Montague Roadhouse, Km 132 Klondike Highway, 61°48'35"N 136°7'52"W, *Cody & Cody 38082*, 28 July 2002 (DAO).

This species is frequent in the southern part of the Territory west of longitude 137°W and north of latitude 64°N but has not previously been found adjacent to the Klondike Highway.

Festuca saximontana Rydb., Rocky Mountain Fescue – YUKON: gravel beside road, Alaska Highway 8 km west of White River, 62°3'15.6"N 140°38'20.5"W, *Cody & Cody 37886, 37887*, 20 July 2002 (DAO).

The specimens cited above are an extension of the known range in the Territory of about 100 kilometers northwest of a site just northwest of Kluane Lake.

Glyceria striata (Lam.) Hitchc. var. *stricta* (Scribn.) Fern., Fowl Marina Grass – YUKON: moist muddy organic soil, along road from Dalton Post to Wade Lakes, 60°07.765'N 137°04.105'W, *P. Caswell 650*, 4 Aug. 2002 (DAO).

This plant was considered rare in the Territory by Douglas et al. (1981). Cody (1996) knew it only in the southeast as far west as just west of Watson Lake. The specimen cited above from between the Haines Highway and Kluane National Park is from a site about 450 kilometers to the west. It is however known from British Columbia.

Hordeum brachyantherum Nevski – YUKON: disturbed area in townsite, Big Salmon Village at confluence of Yukon River, 61°53'N 134°55'W, *B. Bennett 02-292*, 7 Aug. 2002 (DAO).

Cody (1996) considered this species to be introduced at Dawson City but native and rare at Carcross. Sites in the vicinity of Whitehorse (Cody et al. 2001) were considered to be introduced. The specimen cited above was probably also introduced.

Koeleria macrantha (Ledeb.) Schultes, June Grass – YUKON: south aspect-xeric-sage/graminoid-forbs of low compact growth, Site YPC103 near confluence of Pelly and Yukon rivers, 62°48'16"N 137°19'35.9"W, *G. Brunner 536-01*, 3 Aug. 2001 (DAO) (determined by S. Darbyshire); gravel pit just north of the Alaska Highway, Silver City Road, 61°01'22"N 138°19'52"W, *B. Bennett 01-005*, 29 Apr. 2001 (DAO); lower slope south-facing, dry, Five Fingers Coal Mine, Yukon River, 62°12'21"N 136°20'10"W, *B. Bennett 02-295*, 8 Aug. 2002 (DAO).

Douglas et al. (1981) considered this species rare in the Territory. The first specimen cited above was collected just southwest of the Pelly River Ranch at 62°50'20"N 137°11'40"W by M. Johansen in 1989 (DAO) (Cody 1996); the second specimen is an extension of about 60 kilometers northwest of a site adjacent to Haines Junction; the third specimen is from a site about 40 kilometers southeast of a site near Minto (Cody 1996).

Poa annua L., Annual Blue Grass – YUKON: vicinity of campground, Rancheria, at mile 710 Alaska Highway (60°05'N 130°36'W), *S. L. Welsh & G. Moore 7539*, 29 June 1968 (AKA, photo DAO) (determined by R. J. Soreng).

Cody (1996) knew this introduced species from only five sites in the Territory. The specimen cited above is about 100 kilometers west of a site adjacent to the southern Canol Road.

Poa interior Rydb. (*P. nemoralis sensu* Cody 1996) – YUKON: in subalpine meadow, Onion Lake, ca. 46 mi S of Haines Junction, *G. W. & G. G. Douglas 7089*, 12 Aug. 1973 (AKA, photo DAO) (determined by R. J. Soreng); common on steep, open, west-facing prairie slopes, Conglomerate Mountain on Dawson-Whitehorse road, 61°38'N 135°53'W, *Calder & Gillett 25770*, 22 June 1960 (DAO); common on south-facing, prairie slope with scattered aspen, Mile 30 on road to Dawson from Stewart Crossing, 63°33'N 137°25'W, *Calder & Gillett 25037*, 4 June 1960 (DAO); grown on open southern slope, Pelly Ranch (ca. 62°49'N 136°34'W), *J. Y. Tsukamoto s.n.*, 23 July 1960 (DAO); silt bluff, south-facing, on Porcupine River, 1.5 km upstream from junction between Rat Indian Creek and Porcupine River, 67°34'N 138°21'W *L. Cwyner 977*, 22 July 1976 (DAO) (determined by M. Barkworth); dry open exposed gravel ridge overlooking delta, west side of river on ridge campsite, Lower Blow River Delta, 69°53'N 137°10'W, *H. L. Dickson & D. L. Allen 5324*, 26 July 1982 (DAO); open meadow-abandoned beaver pond, Deadman Creek, 60°20.2'N 133°03.5'W, *S. Withers SW01-126*, 16 July 2001 (DAO) (determined by S. Darbyshire).

Yukon specimens previously mapped as *Poa nemoralis* by Cody (1996) have been revised to *P. interior*. In addition, the specimens cited above which were inadvertently missed have now been mapped. (See new map Figure 1).

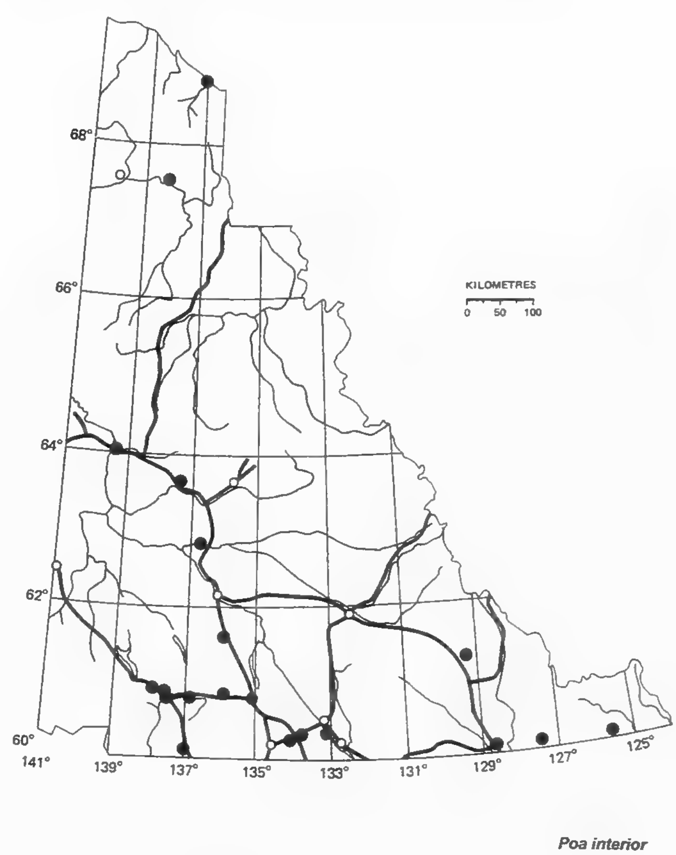

FIGURE 1. New distribution map for *Poa interior* in the Yukon Territory.

Poa leptocoma Trin. – YUKON: steep gravelly slope adjacent to Alaska Highway 3 km east of Snag Junction, 62°12'42.3"N 140°41'33.1"W, *Cody & Cody 37863*, 20 July 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 175 kilometers northwest of a site in Kluane National Park.

Poa secunda Presl, Sandberg Bluegrass – YUKON: commonly found growing on the base of the bluff and occasionally on midslope, Minto Bluff, 62°36'18"N 136°51'06"W, *B. Bennett 02-013*, 9 June 2002 (DAO).

The specimen cited above is an extension of about 175 kilometers northwest of a site north of Whitehorse (Cody 1996). To the north the only other site in the Territory is in the vicinity of Dawson City.

Puccinellia interior Th. Sor. – YUKON: gravel roadside, Top of the World Highway Km 102, 64°05'33"N 140°55'22"W, *Cody & Cody 38002*, 26 July 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 75 kilometers west from the vicinity of Dawson City.

Setaria viridis (L.) Beauv., Green Bristlegrass (Figure 2) – YUKON: in crack at edge of Extra Foods parking lot, downtown Whitehorse, *B. Bennett 98-437*, 14 Oct. 1988 (B. Bennett Herbarium, photo DAO).

The specimen cited above is a new introduction to the *Flora of the Yukon Territory* (Cody 1996). This species which is introduced from Eurasia is known across Canada from Newfoundland to British Columbia and has been found at Fort Simpson in the Northwest Territories. The genus *Setaria* can be separated from the genus *Panicum* as follows:

A. Spikelet surrounded by 1-many distinct or more or less connate bristles, these forming an involucre .... *Setaria*

B. Spikelet not subtended by bristles .... *Panicum*

Stipa comata Trin. & Rupr., Needle-and-thread – YUKON: 45° silty sand south-facing slope with *Artemesia frigida* and *Calamagrostis purpurascens*, Dutch Bluff, Yukon River, 61°55'N 135°03.99'W, *B. Bennett 02-289*, 7 Aug. 2002 (DAO).

Cody (1996) knew this species in the Territory from only four sites south of 63°N. Cody et al. (2003) added an additional site just east of Haines Junction. The specimen cited above is from a site about 60 kilometers southeast of Carmacks.

Stipa nelsonii Scribn. ssp. *dorei* Barkworth & Maze – YUKON: treeless rocky slope overlooking lake, Snafu Lake Camp Site, 60°08'10"N 133°48'23.6"W, *Cody & Cody 37567*, 28 July 2001 (DAO); open area adjacent to *Populus tremuloides* woodland overlooking lake, 7 km east of Tagish Bridge, 60°19'5"N 134°10'17"W, *Cody & Cody 37938*, 23 July 2002 (DAO).

Cody (1996) knew this species from only six sites in the Territory north to about latitude 61°N. Cody et al. (2001) added an additional site in the vicinity of the Carcross Dunes. The specimens cited above are from east and southeast of the Carcross Dunes site.

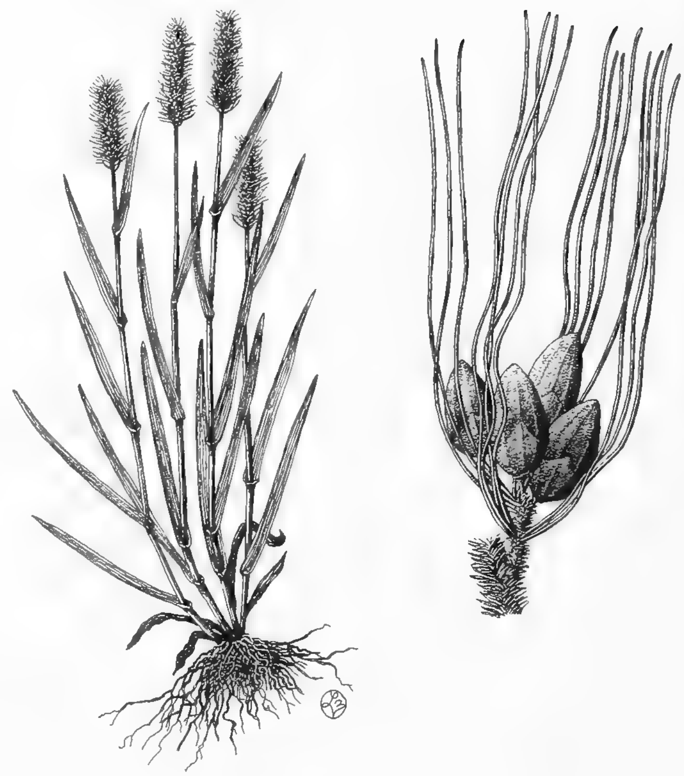

FIGURE 2. *Setaria viridis*, Green Bristlegrass (drawn by Lee Mennell).

Stipa richardsonii Link (*Achnatherum richardsonii* (Link) Barkw.), Spreading Needlegrass – YUKON: on steep slope found on lower and mid-slope with *Arabis*, *Arctostaphylos uva-ursi*, *Festuca saximontana* and *Poa*, hill across Tagish Road from Crag Lake, 60°15'30"N 134°28'53"W, *B. Bennett 01-008*, 19 May 2001 (DAO); summit of hill behind Carcross Cutoff, south-facing, pine forest Cowley Creek, 60°35.66'N 134°52.96'W, *B. Bennett 99-300*, 6 Aug. 1999 (DAO).

Douglas et al. (1981) knew this rare species in the Territory from only one locality from adjacent to the Alaska Highway just east of the Atlin Road junction (*Calder & Gillett 26477*, DAO). Cody (1996) mapped three additional sites in the vicinity of Whitehorse. The first specimen cited above is the southernmost yet found in the Territory.

Vahlodea atropurpurea (Wahlenb.) Fries, Mountain Hairgrass – YUKON: Site YPN 120, 63°06'39.8"N 133°20'15"W, *G. Brunner 568-01*, 6 Aug. 2001 (DAO).

Cody (1996) knew this taxon from only six localities: adjacent to the North Canol Road, adjacent to the South Macmillan River and near Bennett Lake. Additional sites have since been found east of the Canol Road (Cody et al. 1998 and 2000). The specimen cited above is from a site about 50 kilometers northeast of the Macmillan River site.

CYPERACEAE

Carex albo-nigra Mack., Two-toned Sedge – YUKON: Volcano Mountain, 62°55'N 137°23'W, *G. Brunner 521-01*, 3 Aug. 2001 (DAO); moist scree with organic component on north-facing slope, Vulcan Mountain, Kluane National Park, 60°54.712'N 138°29.484'W, *P.*

Caswell 527, 15 July 2002 (DAO); moist organic soil on southwest facing slope on old semi-abandoned road north of Donjek River bridge, 61°42.209'N 139°48.376'W, *P. Caswell 196*, 25 June 2002 (DAO).

Cody (1996) knew this rare species in the Territory from seven localities south of latitude 63°N, three of which were in Kluane National Park. The first specimen cited above is the northernmost yet found in the Territory. Cody et al. (2000) added another site south of Ross River and Cody et al. (2001) another site in the extreme southeast.

Carex athrostachya Olney – YUKON: moist soil by lake, Five Mile Lake Campground, 5 km N of Mayo, 63°39'11.1"N 135°53'14.2"W, *Cody & Cody 37641*, 1 Aug. 2001 (DAO).

Douglas et al. (1981) considered this species rare in the Territory on the basis of a specimen collected by R. T. Porsild on the shores of a small bog pond in the vicinity of Mayo, 63°37'N 135°55'W, on 12 May 1967 (Porsild 1975). The specimen cited above from nearby is only the second yet found in the Territory.

Carex atrosquama Mack. – YUKON: steep gravelly slope adjacent to the Alaska Highway 3 km east of Snag Junction, 62°12'42.3"N 140°41'33.1"W, *Cody & Cody 37861*, 20 July 2002 (DAO); cleared gravel by highway, Top of the World Highway Km 92, 64°6'6"N 140°46'47"W, *Cody & Cody 38024*, 26 July 2002 (DAO).

The first specimen cited above is an extension of the known range in the Territory about 190 kilometers northwest from the south end of Kluane Lake (Cody 1996) and the second specimen is an extension of the known range of about 100 kilometers west of the Dempster Highway.

Carex capillaris L. ssp. *chlorostachys* (Steven) Löve et al. – YUKON: Klondike River near mouth of Little Klondike, 64°02'00"N 137°41'30"W, *G. Brunner 440*, 3 July 2001 (DAO).

The specimen cited above is the first known to Cody (1996) between latitudes 64°N and 66°N east of the Dempster Highway. It is an extension of about 60 kilometers northeast of a site southwest of the south end of the Dempster Highway.

Carex crawfordii Fern. – YUKON: sandy lake shore, Kusawa Lake, 60°34'59.2"N 136°08'26.5"W, *W. J. Cody 37718*, 13 July 2002 (DAO); meadow adjacent to RCMP foundation, Fort Selkirk, 62°46'34.4"N 137°23'35.9"W, *Cody & Kennedy 37749A*, 16 July 2002 (DAO).

This species was considered rare in the Territory by Douglas et al. (1981). The specimen from south of Whitehorse cited above is an extension of the known range in the Territory of about 250 kilometers south of a site mapped by Cody (1996) from adjacent to the Pelly River. The second specimen is from about 85 kilometers west of a site adjacent to the Pelly River.

Carex eleusinoides Turcz. – YUKON: moist organic soil with pumice component, down old road west of Alaska Highway north of Donjek River bridge, 61°42.209'N 139°48.376'W, *P. Caswell 205*, 2 June 2002 (DAO); gravelly silt near water line, Klondike River, 64°01'N 137°51'W, *G. Brunner 546*, 8 July 2001 (DAO); approximately 2 miles downstream from O'Brian Creek on Klondike River, 64°01'46"N 38°01'00"W, *G. Brunner 547*, 15 July 2001 (DAO).

This species was considered rare in the Territory by Douglas et al. (1981). The first specimen cited above is an extension of the range known to Cody (1996) of about 50 kilometers northwest of the north end of Kluane Lake. The second and third specimens are the first known between latitudes 64°N and 66°N east of the Dempster Highway and are an extension of about 45 kilometers northeast of a site south of the south end of the Dempster Highway.

Carex foenea Willd. – YUKON: Halfway between Orderly House and Robert Luke Cabin, 62°46'34.4"N 137°23'35.9"W, *Cody & Kennedy 37773*, 17 July 2002 (DAO).

Douglas et al. (1981) considered this species rare in the Territory. Cody (1996) knew it only from three sites, two of which were in the vicinity of Pelly Crossing. The specimen cited above came from the same area. Cody et al. (1998) reported an additional site in the vicinity of Beaver Ridge/ Larsen Creek.

Carex limosa L. – YUKON: *Sphagnum* bog, 64°02'N 137°41'W, *G. Brunner 441*, 3 July 2001 (DAO).

The specimen cited above is only the second known between latitudes 64°N and 66°N east of the Dempster Highway (Cody 1996).

Carex loliacea L. – Yukon: damp silty ground, forest *Picea mariana*, *Poa glauca*, *Alnus incana*, *Salix* sp., north side of Klondike River near Parker Creek, 64°01'N 137°51'W, *G. Brunner 592*, 9 July 2001 (DAO); spring alongside road, gravelly, Big Gold Creek/60 Mile River Valley, 64°01'N 140°42'W, *G. Brunner 116*, 23 July 1991 (DAO).

Cody (1996) considered this species uncommon in the Territory although mapped north to the Porcupine River. The specimens cited above are about equally distant east and west of Dawson City.

Carex obtusata Lilj., Blunt Sedge – YUKON: British Mountains, 69°26'N 140°07'W, *A. Martell 625*, 12 July 1979 (DAO); steep south-facing bluffs along Klondike River, 1 mile north of 64°02'00"N 137°41'30"W, *G. Brunner 432*, 2 June 2001 (DAO).

The first specimen cited above is the northernmost yet found in the Territory (Cody 1996). It is an extension of the known range of about 80 kilometers northwest from sites adjacent to the Babbage River. The second specimen cited above is an extension of the known range in the Territory of about 75 kilometers southeast of a site at Sheep Mountain adjacent to the Dempster Highway (Kojima and Brooke 1985).

Carex pachystachya Cham. – YUKON: open meadow, abandoned beaver pond, Deadman Creek, *S. Withers SW01-117*, 16 July 2002 (B. Bennett Herbarium, photo DAO) (determined by A. A. Reznicek).

This species was not included in *The Rare Vascular Plants of the Yukon* (Douglas et al. 1981) because it was widespread in Canada. Cody (1996) knew it from only two localities in the extreme southern Yukon. The specimen cited above is from a site about 25 kilometers south southeast of Whitehorse.

Carex pellita Muhl. ex Willd. – YUKON: silty river bank with *Carex utriculata*, *C. aquatilis*, and *Juncus alpinoarticulatus*, Selwyn, Yukon River, 62°48'06"N 138°15'29"W, *B. Bennett 02-293*, 9 Aug. 2002 (DAO); silty mud at edge of river at high water line with *Juncus alpinoarticulatus*, Brittania Creek, Yukon River, 62°52'28"N 138°42'52"W, *B. Bennett 02-671*, 10 Aug. 2002 (DAO); silty mud at edge of river at high water line with *Juncus alpinoarticulatus*, Kirkman Creek, Yukon River, 62°59'21"N 139°23'07"W, *B. Bennett 02-675*, 10 Aug. 2002 (DAO); river bank in area frequently scoured by river ice, confluence of 12 Mile River, Yukon River, 64°15'11"N 139°43'18"W, *B. Bennett 02-806*, 23 Aug. 2002 (DAO); deeply rooted, edge of river in silty sand bank, Yukon River, 64°33'28"N 140°38'24"W, *B. Bennett 02-807*, 24 Aug. 2002 (DAO).

Cody et al. (2000) reported this plant as a rare species in the Territory based on a specimen from a site below Rink Rapids adjacent to the Yukon River. An additional site was reported from Ear Lake, Whitehorse (Cody et al. 2002). The five sites reported above extend the known range in the Territory about 275 kilometers northwest of the Rink Rapids. Bruce Bennett has found that *Carex pellita* is a common species on the Yukon River between Pink Rapids and White River, less common but can be found downstream and eventually being replaced by *C. saxatilis*.

Carex petasata Dewey – YUKON: east slope adjacent to Alaska Highway ca. 3 km W of Enger Creek, 62°19'12.05"N 140°49'19.9"W, *Cody & Cody 37511*, 25 July 2001 (DAO); open, abandoned mine road surface, Viceroy Mine – Big Rock Zone, 64°02'N 138°17.9"W, *S. Withers SW01-057*, 3 July 2002 (DAO).

The first specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 215 kilometers west of a site west of Carmacks and 245 kilometers northwest of a site adjacent to Haines Junction. The second specimen cited above is at the northern limit in the Territory about 50 kilometers east of a site in the vicinity of Dawson City.

Carex praegracilis Boott – YUKON: meadow adjacent to RCMP foundation, Fort Selkirk, 62°46'34.4"N 137°23'35.9"W, *Cody & Kennedy 37770B*, 17 July 2002 (DAO); sandy lake shore, Kusawa Lake, 60°34'59.2"N 135°08'26.5"W, *W. J. Cody 37717*, 13 July 2002 (DAO).

Douglas et al. (1981) knew this rare species in the Territory from only three localities: Mackintosh, Whitehorse and Carcross. Cody (1996) knew it from 11 sites in the Territory, most of which were south of latitude 61°15'N. The second specimen cited above is a slight extension of range south of Whitehorse.

Carex rossii R. Br., Ross' Sedge – YUKON: decomposed bedrock, South Fork bluffs, Klondike River, 64°01'N 138°9'W, *G. Brunner 446-01*, 14 July 2001 (DAO); steep south-facing bluffs along Klondike River 1 mile north of 64°02'N 137°41'30"W, *G. Brunner 433*, 2 June 2001 (DAO).

The specimens cited above are only the third and fourth collections known from north of latitude 64°N (Cody 1996) which are from about 80 kilometers east of a site adjacent to Dawson. To the south, the nearest known site is adjacent to the northern South Canol Road about 300 kilometers to the southeast.

Carex stylosa C. A. Mey. – Cody et al. (2000) reported this species which is rare in the Yukon Territory from the Arctic Coast.

The specimen on which it was based (*Hoefs & Smitts 93-37*) was misidentified and the range extension should be deleted. There was also an error in the citation where the latitude should have been 69°23'N not 60°29'N

Carex supina Wahl. ssp. *spaniocarpa* (Steud.) Hultén – YUKON: Steep south-facing bluffs along Klondike River 1 mile north of 64°02'N 137°41'30"W, *G. Brunner 434*, 2 June 2001 (DAO).

The specimen cited above is the first known in the Territory north of 64°N east of the Dempster Highway. The nearest known site is about 75 kilometers to the northwest cited by Kojima & Brooke (1985).

Carex sychnocephala Carey – YUKON: damp, fine gravel with organic component, at base of highway embankment, Alaska Highway just north of Copper Joe Creek, 61°19.814'N 138°56.805'W, *P. Caswell 570*, 21 July 2002 (DAO).

Douglas et al. (1981) considered this species rare in the Territory. The specimen cited above is an extension of the range known to Cody (1996) of about 175 kilometers northwest by west of a site west of Whitehorse.

Carex viridula Michx. – YUKON: on moist shoreline of Nares Lake south of Carcross, 60°9'20"N 134°40'10"W, *W. J. Cody 38318*, 1 Aug. 2001 (DAO).

This species was considered rare in the Territory by Douglas et al. (1981). The specimen cited above is an extension of the known range to Cody (1996) of about 80 kilometers south of Whitehorse.

Eleocharis uniglumis (Link) Schult. – YUKON: open wet area in old road, adjacent to the Alaska Highway, 61°42.209'N 139°48.376'W, *P. Caswell 204*, 25 June 2002 (DAO); in wet moss by lake shore, Fish Lake, 60°46'3.3"N 135°03'13"W, *W. J. Cody 38246*, 2 Aug. 2002 (DAO).

The species was considered rare in the Territory by Douglas et al. (1981). The first specimen cited above is an extension of the known range to Cody (1996) of about 150 kilometers northwest of a site northwest of Haines Junction and the second specimen is from a site just south of Whitehorse.

Eriophorum brachyantherum Trautv., Short-anthered Cotton-grass – YUKON: Vuntut National Park, vicinity of Snowdrift Camp, 68°21.4'N 139°13.1'W, *P. Caswell PPC-2000-Y-070*, 21 June 2000 (DAO).

The specimen cited above is the northernmost yet found in the Territory (Cody 1996). It is an extension of about 100 kilometers north from sites adjacent to the Porcupine River.

Kobresia simpliciuscula (Wahlenb.) Mack., Simple Kobresia – YUKON: along road track through *Picea glauca* forest, Minto RV Campground, 62°35'N 136°51'W, *Cody & Cody 37678*, 6 Aug. 2001 (DAO).

The nearest site in the Territory (Cody 1996) to the specimen cited above is about 130 kilometers to the southeast adjacent to the Klondike Highway.

Scirpus rollandii Fern. – YUKON: moist organic soil, side road west of Alaska Highway, north of Donjek River bridge, 61°42.209'N 139°48.376'W, *P. Caswell 202*, 25 June 2002 (DAO).

Cody (1996) knew this species in the southwest of the Territory where he considered it rare. The specimen cited above is an extension of the known range of about 100 kilometers northwest of southern Kluane Lake.

JUNCACEAE

Juncus bufonius L. s.l., Toad Rush – YUKON: mud bar, Dezadeash River below Haines Junction, Kluane National Park, 60°45.545'N 137°34.470'W, *P. Caswell 791*, 16 Aug. 2002 (DAO).

The specimen cited above is new to Kluane National Park and is a range extension of about 290 kilometers to the south of a site mapped by Cody (1996) and a site east of Johnson's Crossing reported by Cody et al. (2001).

Juncus filiformis L. – YUKON: in muck by small lake adjacent to the Alaska Highway, 60°51'01"N 135°46'0.5"W, *Cody & Cody 38185*, 1 Aug. 2002 (DAO).

The specimen cited above which is from a site about 75 kilometers west of Whitehorse is the westernmost yet found adjacent to the Alaska Highway.

Luzula arcuata (Wahlenb.) Sw. ssp. *unalaschkensis* (Buch) Hultén – gravel beside road and steep slope, Alaska Highway Km 1918, 62°16'26.1"N 140°45'6.7"W, *Cody & Cody 37851*, 20 July 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 215 kilometers northwest of a site northwest of Haines Junction.

LILIACEAE

Allium schoenoprasum L. ssp. *sibiricum* (L.) Celak, Wild Onion – YUKON: Herschel Island, 69°35'N 139°05'W, *C. E. Kennedy s.n.*, 1 July 1985 (Environment Yukon Herbarium, photo DAO).

The nearest site known to Cody (1996) was adjacent to the Firth River at 69°13'N 139°35'W, about 30 kilometers southwest of the Herschel Island site.

Maianthemum canadense Desf. ssp. *interius* (Fern.) A. & D. Löve, Wild Lily-of-the-Valley – YUKON: common in understory in the riparian white spruce poplar zone, Contact Creek, 60°00'00"N 127°43'44"W, *B. Bennett 01-025*, 25 June 2001 (DAO).

Cody (1994, 1996) suggested that this taxon should be looked for in the Territory and Cody et al. (1998, 2000) reported it from the extreme southeast. The specimen cited above is an extension of the known range of about 80 kilometers southwest from a site adjacent to the Beaver River hotspring.

Tofieldia coccinea Richards., Northern False Asphodel – YUKON: south aspect-xeric-graminoid/forb/lichen meadow, Volcano Mountain, 62°55'N 137°23'W, *G. Brunner 521a-01*, 3 Aug. 2001 (Environment Yukon, photo DAO).

The specimen cited above is from the first known site between latitudes 62°N and 64°N. The nearest site to the north is about 175 kilometers to a site adjacent to the Dempster Highway and to the southwest about 190 kilometers adjacent to the Alaska Highway.

IRIDACEAE

Iris setosa Pall. ssp. *interior* (Anders.) Hultén, Wild Iris – YUKON: at high water level, confluence of 12 Mile River and Yukon River, 64°15'11"N 139°43'18"W, *B. Bennett 02-743*, 23 Aug. 2002 (DAO).

Cody (1996) knew this rare species in the Territory from only three locations, two from near the western end of the Alaska Highway and one from adjacent to the Takhini River west of Whitehorse. The specimen cited above is an extension of the known range of about 225 kilometers to the north of the sites near the Alaska border. Only four plants were observed.

ORCHIDACEAE

Spiranthes romanzoffiana Cham. & Schlecht., Hooded Ladies'-tresses – YUKON: tussocks near bog, east of Haines Highway, 60°08.570'N 136°58.469'W, *P. Caswell 453*, 13 July 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 120 kilometers southwest of Whitehorse.

SALICACEAE

Salix alaxensis (Anderss.) Cov. ssp. *longistylis* (Rydb.) Hultén – YUKON: beside recreation centre in middle of town, Beaver Creek, 62°22'56"N 140°52'41"W, *B. Bennett 01-102*, 12 June 2001 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 140 kilometers northwest of a site near the north end of Kluane Lake.

Salix glauca L. var. *acutifolia* (Hook.) C. Schneider – YUKON: Mt. Merrill, 60°06'N 124°45'W, *G. Brunner*, 1994 (DAO).

The specimen cited above is about 90 kilometers east of the easternmost site of *Salix glauca* sl. mapped by Cody (1996).

Salix pseudomyrsinites (Anderss.) Ball ex Hultén (*S. novae-angliae* Anderss.) – YUKON: along Bennett Lake just above high water mark, Carcross Dunes, 60°10'30"N 134°43'26"W, *B. Bennett & G. Argus 99-548*, 29 Aug. 1999 (DAO) (determined by G. Argus).

The nearest site of this species known to Cody (1996) is in the vicinity of Whitehorse, about 60 kilometers to the northwest.

Salix rotundifolia Trautv. ssp. *dodgeana* (Rydb.) Argus – YUKON: *Dryas alaskensis* tundra, Mount Casca border Monument 97, 65°21'25"N 141°00'00"W, *B. Bennett & M. B. Cook 02-519*, 27 June 2002 (DAO) (determined by G. Argus).

The specimen cited above from adjacent to the Alaska border is from a site about 70 kilometers northwest of the nearest site known to Cody (1996).

URTICACEAE

Urtica dioica L. ssp. *gracilis* (Ait.) Selander, Stinging Nettle – YUKON: dwelling mound, Forty Mile Historic Site at the confluence of Forty Mile and

Yukon rivers, 64°25'N 140°30'W, *C. E. Kennedy 44*, July 2000 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 50 kilometers northwest of the vicinity of Dawson City.

POLYGONACEAE

Polygonum lapathifolium L., Willow Weed, Pale Smartwood – YUKON: wetland *Carex* fen, uncommon silty mud beside beaver pond, 60°07'00"N 124°15'2"W, *B. Bennett 98-609*, 16 June 1998 (DAO).

This species was considered rare in the Territory by Douglas et al. (1981). The specimen cited above is an extension of the known range in the Territory of about 700 kilometers southeast of sites in the vicinity of Carmacks.

Rheum rhabarbarum L. (*R. rhaponticum* L.) Rhubarb – YUKON: adjacent to garage near machine shop, Fort Selkirk, 62°46'34.4"N 137°23'35.9"W, *Cody & Kennedy 37799*, 17 July 2002 (DAO).

Cody et al. (2001) and (2002) reported Rhubarb growing wild at Silver City and Destruction Bay. The specimen cited above is the third known cited where it was growing wild.

Rumex crispus L., Curled Dock – YUKON: moist shore of small lake between Ross River and Campbell Highway, 61°58'7"N 132°38'34"W, *Cody & Cody 37961*, 24 July 2002 (DAO).

The specimen cited above is the sixth site in the Territory for this introduced species. Cody (1996) knew it from the vicinity of Dawson City and it has since been reported from just west of Whitehorse, Haines Junction and adjacent to the Alaska Highway near the Alaska border (Cody et al. 2002).

CHENOPODIACEAE

Atriplex alaskensis S. Watson, (*A. patula sensu* Cody (1996), *A. patula* var. *alaskensis* (S. Wats.) Welsh), Alaskan Orache (Figure 3) – YUKON: alkaline flat, Takhini Salt Flats, 60°51.2'N 135°43.23'W, *Bennett & Parker 98-431*, 2 Sept. 1998 (B. Bennett Herbarium, photo DAO) (determined by P. W. Ball); alkaline flats, between the salt flat and the highway in the area of the fence, Takhini Salt Flats, 60°51'23"N 135°42'55"W, *B. Bennett 01-168*, 23 Aug. 2001 (B. Bennett Herbarium, photo DAO); occasional in wet alkaline margin of a brackish slough, Mile 484.5 Alaska Highway west of Whitehorse, *R. L. Taylor 4094*, 14 July 1959 (DAO); common around clay margins of dried up alkaline pond, east of Haines Junction at Mile 985 Alaska Highway, 60°48'N 136°45'W, *Calder & Kukkonen 28252*, 14 Aug. 1960 (DAO); common around clayey margin of alkaline lake, between Minto and Pelly Crossing on Dawson-Whitehorse road, approximately 62°46'N 136°36'W, *Calder & Kukkonen 28095*, 10 Aug. 1960 (DAO).

Cody (1996) considered the Calder & Cody specimens as introductions from Europe (*A. patula*). *Atriplex alaskensis* should now be added to the Yukon Flora and the list of rare plants of the Territory (Douglas et al. 1981). The Taylor specimen cited above was the basis for the drawing published in the Yukon Flora as *A. patula*.

Atriplex subspicata (Nutt.) Rydberg – YUKON: grassy area in open alkaline salt ponds, Mayo Road, Dillabough's Grazing Lease, 60°55'54"N 135°10'14"W, *B. Bennett 02-649*, 19 Aug. 2002 (DAO).

Cody (1996) knew this species from a single locality adjacent to a saline pond just west of Whitehorse. The specimen cited above from just north of Whitehorse is only the second known from the Territory.

Chenopodium capitatum (L.) Asch., Strawberry-blite – YUKON: disturbed gravelly soil, roadstop, Atlin Road just north of BC border, 60°00'09"N 133°47'42.1"W, *Cody & Cody 37546*, 28 July 2001 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 60 kilometers to the southwest from a site in the vicinity of Johnson's Crossing.

Corispermum ochotense Ignatov var. *alaskanum* Mosyakin (*C. hyssopifolium sensu* Cody 1996) – YUKON: river bar in loose aluvial sand between *Salix exigua* and river with *Tanacetum bipinnatum*, *Potentilla anserina* and *Aster falcatus*, Yukon River at confluence of Nester Creek, 64°38'22"N 140°52'52"W, *Bennett & Mulder 02-665*, 25 Aug. 2002 (DAO); river bar in loose alluvial sand between *Salix exigua* and river with *Tanacetum bipinnatum*, *Potentilla anserina* and *Aster falcatus*, Yukon River, 64°22'19"N 140°26'49"W, *Bennett & Mulder 02-740*, 24 Aug. 2002 (DAO).

The specimens cited above are the first yet found in the Territory.

PORTULACACEAE

Claytonia megarrhiza (A. Gray) Parry, Alpine Springbeauty (Figure 3) – YUKON: alpine tundra, three plants seen at base of a long scree slope near a very small stream, northwest side of Wade Mountain, Kluane National Park, 61°18'N 139°33'W, *P. Caswell 236*, 28 June 2002 (DAO).

This species, which is new to the *Flora of the Yukon Territory* (Cody 1996), should be added to the list of rare plants of the Territory (Douglas et al. 1981). Porsild and Cody (1980) knew it from three sites in the Mackenzie Mountains in the Continental Northwest Territories and McJannet et al. (1995) knew it from four sites in that area in the *Rare Vascular Plants in the Northwest Territories*. To the south Douglas et al. (2002) mapped three sites in the extreme southeast of British Columbia where it was considered rare.

Montia fontana L., Blinks – YUKON: aquatic, growing in the shallows (10-30 cm) in a backwater slough, Lewes Marsh, 60°34'N 134°35'W, *B. Bennett 00-1091*, 25 June 2000 (DAO) (determined by C. Parker and W. J. Cody).

Cody (1996) knew this rare plant in the Territory only from a single locality on the Arctic Coast where it was collected by Erling Porsild in 1934 (CAN, photo DAO). In addition a second specimen was collected by Cody on Herschel Island in 1999 (Cody et al. 2001). This is a circumpolar, low-arctic species, which was considered rare in the Territory by Douglas et al. (1981). To the east of the location cited above it is known from the southern Mackenzie Mountains in the

FIGURE 3. *Claytonia megarrhiza,* Alpine Springbeauty (drawn by Lynne Bartosch).

former District of Mackenzie, and to the west in essentially coastal regions of Alaska and British Columbia.

CARYOPHYLLACEAE

Cerastium arvense L., Field Chickweed – YUKON: wet roadside ditch, Top of the World Highway Km 100, 64°05'53"N 140°54'43"W, *Cody & Cody 38011*, 26 July 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 100 kilometers west of the vicinity of Dawson City.

Minuartia dawsonensis (Britt.) House – YUKON: steep slope by Alaska Highway, 8 km west of White River, 62°3'15.6"N 140°38'20.5"W, *Cody & Cody 37880*, 20 July 2002.

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 125 kilometers northwest of a site adjacent to Kluane Lake.

Minuartia elegans (Cham. & Schlecht.) Schischk. – YUKON: *Dryas alaskensis* heath, 30° southwest-facing large talus dolomite boulders, summit of mountain on Canadian side of Mount Casca, 65°21'37"N 140°59'34"W, *B. Bennett & M. B. Cook 02-543*, 27 June 2002 (B. Bennett Herbarium, photo DAO).

The specimen cited above from adjacent to the Alaska border is an extension of the known range of about 75 kilometers northwest of the nearest site in the Ogilvie Mountains.

Minuartia macrocarpa (Pursh) Ostenf. – YUKON: alpine tundra, spotty occurrence in raised rocky mounds, mountain between Kusawa and JoJo Lake, 60°35'47"N 136°15'19"W, *B. Bennett 97-681*, 19 Sept. 1997 (DAO).

The specimen cited above is an extension of the known range in the southwest of the Territory of about 80 kilometers southeast of a site northwest of Haines Junction.

Minuartia yukonensis Hultén – YUKON: coarse gravel and small rocks of a stream's outwash, Upper Joe Creek, Kluane National Park, 61°12.861'N 139°03.863'W, *P. Caswell 585*, 24 July 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 225 kilometers west of a site north of Whitehorse.

Silene involucrata (Cham. & Schlecht.) Bocquet ssp. *tenella* (Tolm.) Bocquet – YUKON: meadow between Stone House and river near Fort Selkirk sign, Fort Selkirk, 62°46'34.4"N 137°23'35.9"W, *Cody & Kennedy 37805*, 17 July 2002 (DAO).

The specimen cited above is from a site between sites in the vicinity of Mayo and south of latitude 62°.

Silene williamsii Britton – YUKON: talus lower slope of southwest-facing bluff, Yukon River, Minto Bluff, 62°37'06"N 136°57'41"W, *B. Bennett 02-678*, 9 Aug. 2002 (B. Bennett Herbarium, photo DAO); common on base of slope across from Brittania Creek growing with *Artemisia frigida* and *Calamagrostis purpurascens*, Yukon River, 62°52'28"N 138°42'56"W, *Bennett 02-443*, 10 Aug. 2002 (B. Bennett Herbarium, photo DAO).

This species was considered rare in the Territory by Douglas et al. (1981) on the basis of 3 collections from south and southwest of Dawson City.

Silene vulgaris (Moench) Garcke, Bladder Campion – YUKON: gravelly soil in old field with grass and sweet clover, west of Mayo airport, 63°37'01.4"N 135°58'20.9"W, *Cody & Cody 37665*, 4 Aug. 2001 (DAO).

The specimen cited above of this introduced species in the Territory (Cody 1996) was previously known only from an area just east of Dawson.

Stellaria umbellata Turcz. – YUKON: wet scree cushion in zinc moss, Wade Mountain, Kluane National Park, 61°18.450'N 139°30.921'W, *P. Caswell 354*, 7 July 2002 (DAO).

Douglas et al. (1981) considered this species as rare in the Territory. Cody (1996) knew it from only three widely separated sites. The specimen cited above is from a site about 60 kilometers northwest of a previously known site in Kluane National Park.

NYMPHAEACEAE

Nuphar polysepalum Engelm., Yellow Pond-lily – YUKON: shallow water along shore of lake, Tatchun Lake Campground, 62°17'52.8"N 136°08'11.4"W, *Cody & Cody 37626*, 30 July 2001 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 120 kilometers to the north, south of Mayo.

RANUNCULACEAE

Pulsatilla ludoviciana (Nutt.) Heller, Prairie-crocus – YUKON: steep grassy slope on ridge northeast of Woodburn Creek, Tintina Trench, Ddhaw Ghro, 63°08'N 136°05'W, *C. E. Kennedy 4*, 27 July 2001 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 100 kilometers east northeast of a site north of the junction of the Pelly and Yukon rivers.

Ranunculus aquatilis L. var. *subrigidus* (W. B. Drew) Breitung – YUKON: near South Fork intake, Klondike River on edge of beaver dam in old ditch, 64°0'30"N 138°12'00"W, *G. Brunner 549*, 22 July 2002 (DAO).

The nearest site known to Cody (1996) of this uncommon variety was about 60 kilometers to the north adjacent to the Dempster Highway.

Ranunculus occidentalis Nutt. var. *brevistylis* Greene, Western Buttercup – YUKON: alpine tundra, valley above treeline, Macmillan Pass, 63°15'N 130°02'W, *J. Basinger s.n.*, June 1982 (DAO).

Douglas et al. (1981) considered this species rare in the Territory. The specimen cited above is the northernmost yet found in the Territory and is an extension of the known range of about 250 kilometers northeast of a site adjacent to the northern South Canol Road.

PAPAVERACEAE

Papaver croceum Ledeb. – YUKON: by garbage along trail in *Picea glauca*, *Pinus*, *Populus tremuloides* woodland, Whitehorse, near Hidden Lake, 60°35'00.5"N 135°51'00.2"W, *Cody & Cody 37678A*, 9 Aug. 2001 (DAO); in gravel beside car parking spot, 11 Chalet Crescent, Whitehorse, 60°55'54.7"N 135°10'26.5"W, *W. J. Cody 37711*, 12 July 2002 (DAO) (determined by H. Solstad).

This species is a garden escape which has not previously been recorded from the Whitehorse area. In addition Heidi Solstad revised three collections previously determined as *Papaver nudicaule* (Dawson, *Calder & Billard 3121* (DAO), Halfway Lakes area 15 miles north of Mayo, *Calder & Gillett 4176* (DAO) and Tower Hill, Tagish, *R. Rosie 798* (DAO)) to *P. croceum*. *P. nudicaule* ssp. *nudicaule* should be replaced by *P. croceum* in the flora (Cody 1996, 2000).

BRASSICACEAE (CRUCIFERAE)

Alyssum obovatum (C. A. Meyer) Turcz. (*A. americanum* Greene) – YUKON: 45° talus southwest-facing slope, Yukon River, 1 km east of Alaska/Yukon border, 64°41'05"N 140°57'30"W, *Bennett & Mulder 02-666*, 25 Aug. 2002 (B. Bennett Herbarium, photo DAO) (determined by G. A. Mulligan).

Douglas et al. (1981) considered this species too widespread to include it in *The Rare Vascular Plants of the Yukon*. Cody (1996) knew it from only eleven sites north of latitude 62°N. The specimen cited above is a slight extension of the known range in the Territory about 50 kilometers to the northwest of another site adjacent to the Yukon River.

Arabis caucasica Willd., Wall Rock-Cress (Figure 4) – YUKON: garden escape, Alsek Road, Hayes Property, 10 km NW of Haines Junction, 64°47'N 137°41'W, *B. Bennett 01-041*, 12 June 2001 (DAO) (determined by G. A. Mulligan). Submitted to B. Bennett by Carolyn Hayes.

This garden escape has not previously been observed in the Yukon Territory.

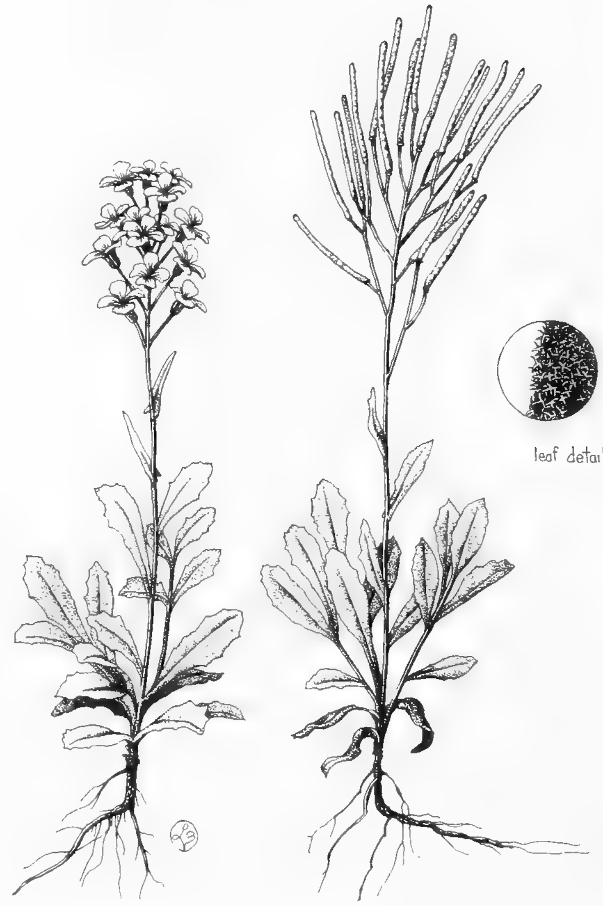

FIGURE 4. *Arabis caucasica* (drawn by Lee Mennell).

Arabis caucasica can be separated from *A. codyi* as follows:

A. Garden escape; cauline and caudex leaves with similar dentate to subdentate margins, flowering stems spreading to ascending; petals 6.5 mm long .... *A. caucasica*

B. Native species; cauline and caudex leaves not similarly dentate to subdentate; flowering stems erect; petals more than 10 mm long .... *A. codyi*

Arabis holboellii Hornem. var. *retrofracta* (Graham) Rydb. – YUKON: gravel beside road and steep slope, Alaska Highway Km 1918, 62°16'26.1"N 140°45'6.7"W, *Cody & Cody 37855*, 20 July 2002 (DAO).

The nearest site adjacent to the Alaska Highway known to Cody (1996) is about 150 kilometers to the southeast in the vicinity of Kluane Lake. There is, however, a site adjacent to a river about 60 kilometers to the east.

Arabis holboellii Hornem. var. *secunda* (Howell) Jepson – YUKON: adjacent to narrow road through woods leading down to Nares Lake southeast of Carcross, 60°9'20"N 134°40'10"W, *Cody & Cody 37934*, 23 July 2002 (DAO) (determined G. A. Mulligan).

Cody (1996) knew this taxon from only four localities in the Territory, west of longitude 135°. Cody (2001) added new sites in the vicinity of Whitehorse and Wolf Lake to the east. The specimen cited above is the southernmost yet found in the Territory.

Armoracia rusticana (Lam.) Gaert., Mess. & Scherb. – YUKON: Hultén (1941-50) reported this species "A specimen of this plant was collected at Stewart R. July 1898 by Andersson (S). It must have been cultivated or have escaped from cultivation". Hultén (1968) mapped the worldwide distribution of this species with a single dot in the Territory and Welsh (1974) sub *Rorippa armorocia* (L.) A. S. Hitchc. stated "Cultivated for the root; in southern Alaska and Yukon, persisting; introduced from Europe". Fortunately this species was overlooked by Cody when preparing the *Flora of the Yukon Territory* (1996); since the Anderson specimen was recently borrowed from the Swedish Museum of Natural History, Stockholm and was revised by Gerald A. Mulligan to *Rorippa barbareifolia* (DC.) Kitagawa, an amphi-Berigian, nonarctic species which extends across Alaska to central Yukon Territory, the Porcupine River valley, the central Richardson Mountains and the Fort McPherson area south of the Mackenzie Delta.

Brassica rapa L., Bird rape – YUKON: roadside gravel, Alaska Highway, near Kluane Wilderness Camp Km 1791, *B. Bennett 01-095*, 24 July 2001 (DAO).

The specimen cited above of this introduced species is an extension of the known range in the Territory of about 175 kilometers northwest of a site adjacent to the Haines Highway. It may have resulted from roadside seeding.

Camelina sativa (L.) Cranz, Falseflax (Figure 5) – YUKON: disturbed site, Whitehorse Shipyards, 60°43'34"N 135°03'12"W, *B. Bennett 01-150*, 28 Aug. 2001 (B. Bennett Herbarium, photo DAO) (determined by G. A. Mulligan).

The specimen cited above is new to the *Flora of the Yukon Territory* (Cody 1996). It is a Eurasian introduction which is known in Canada from New Brunswick to British Columbia and north into southern District of Mackenzie.

The genus *Camelina* can be separated from the genus *Alyssum* as follows:

A. Styles usually 2-3 mm long; silicles oval-elliptic to egg-shaped, usually at least 5 mm long; seeds numerous; petals often shallowly bilobed; annual *Camelina*

B. Styles not over 1 mm long; silicles oval in outline, less than 5 mm long; petals not bilobed; perennial . . . . *Alyssum*

Capsella bursa-pastoris (L.) Medic., Shepherd's-purse – YUKON: level gravel area, Campbell Highway Km 380, 62°02'34.2"N 132°52'02.2"W, *Cody & Cody 37591*, 30 July 2001 (DAO); growing beside *Artemisia tilesii* by narrow road through woodland, Pelly Farm Road, 62°51'22.2"N 137°00'34"W, *Cody & Kennedy 37821B*, 17 July 2002 (DAO); gravel, Pickhandle Lake, 63°02'22.2"N 138°23'15.8"W, *Cody & Cody 37834*, 20 July 2002 (DAO).

The first specimen cited above of this introduced species is from a site between two sites adjacent to the Campbell Highway (Cody 1996) in the vicinity of Carmacks. One of sites is 175 kilometers to the west and the other is about 185 kilometers to the southeast. The second and third specimens are from sites between Keno and Carmacks (Cody 1996).

Cardamine bellidifolia L., Alpine Bittercress – YUKON: Herschel Island, 69°35'N 139°05'W, *C. E. Kennedy s.n.*, 20 July 1985 (DAO).

The nearest sites known to Cody (1996) were from the north coast about 30 kilometers to the west and near the Firth River about 30 kilometers to the southwest.

Descurainia incisa (Engelm. ex A. Gray) Britton var. *incisa*, Tansy Mustard – YUKON: gravel roadside, rare, Dempster Highway Km 98, 64°42'N 138°24'46"W, *Cody & Cody 38056*, 27 July 2002 (DAO) (determined by G. A. Mulligan).

Cody et al. (2001) reported this species as new to the Territory and Cody et al. (2002) added additional sites adjacent to the Alaska Highway north of latitude 62°N. The specimen cited above is from the first known site adjacent to the Dempster Highway.

Draba aurea M. Vahl, Golden Draba – YUKON: Site KPL 110, 62°15'09.6"N 137°41'03"W, *G. Brunner 591-01*, 8 Aug 2001 (Environment Yukon Herbariam, photo DAO) (determined by G. A. Mulligan).

The specimen cited above is the northernmost yet found in the Territory (Cody 1996). It is an extension of the known range of about 50 kilometers from a site south of latitude 62°N.

Draba corymbosa R. Br. – YUKON: Herschel Island, 69°35'N 139°05'W, *C. E. Kennedy s.n.*, 10 Aug. 1985 (Environment Yukon Herbarium, photo DAO) (determined by G. A. Mulligan).

FIGURE 5. *Camelina sativa*, Falseflax (drawn by Lee Mennell).

The nearest site known to Cody (1996) was from near the Firth River about 30 kilometers to the southwest.

Draba crassifolia Graham – YUKON: sandy moist soil in eroded area, ridge south of Donjek Glacier, 61°08.277'N 139°31.170'W, *P. Caswell 403*, 8 July 2002 (DAO) (determined by G. A. Mulligan).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) northwest of sites in Kluane National Park.

Draba glabella Pursh – YUKON: steep south-facing bluffs along Klondike River, 1 mile north of 64°02'00"N 137°41'30"W, *G. Brunner 438*, 2 June 2001 (DAO) (determined by G. A. Mulligan).

The specimen cited above is from a site about 70 kilometers east of a site in the vicinity of Dawson City (Cody 1996).

Draba nemorosa L., Wood Whitlow-grass – YUKON: disturbed farm area, Black Sheep airline base, Mayo, 63°35.26'N 135°51.83'W, *B. Bennett 00-1193*, 2 July 2000 (DAO) (determined by G. A. Mulligan).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 110 kilometers northeast of a site west of longitude 137°W and north of the Pelly River.

Draba ogilviensis Hultén – YUKON: summit of small peak south of Donjek Glacier, Kluane National Park, 61°08.318'N 139°31.132'W, *P. Caswell 392*, 8 July 2002 (DAO) (determined by G. A. Mulligan).

Douglas et al. (1981) considered this species rare in the Territory. The specimen cited above is the westernmost yet known in Kluane National Park.

Draba palanderiana Kjellm. – YUKON: dry alpine *Dryas* heath with *Dryas alaskensis*, *Silene acaulis*, *Synthyris borealis*, *Podistera macounii* and lichens, summit of mountain, calcareous dolomite talus, 65°21.37'N 140°59.34'W, *B. Bennett 02-523*, 27 June 2002 (DAO).

The specimen cited above from adjacent to the Alaska border is an extension of the known range in the Territory of about 60 kilometers to the north of a site mapped by Cody (1996).

Draba porsildii G. A. Mulligan – YUKON: wet scree, Wade Mountain, Kluane National Park, 61°18'N 139°33'*W, P. Caswell* 240, 2 June 2002 (DAO) (determined by G. A. Mulligan).

Douglas et al. (1981) considered this species rare in the Territory on the basis of three specimens from Kluane National Park and one from the South Canol Road southwest of Ross River. Cody (2003) cited a specimen from west of the three sites in Kluane National Park. The specimen cited above is from an additional site in the Park about 70 kilometers north of the last site.

Draba stenoloba Ledeb. – YUKON: Donjek Valley, 61°25.689'N 139°53.074'W, *R. Maraj s.n.*, 29 June 2002 (DAO) (determined by G. A. Mulligan).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 90 kilometers northwest of a site in Kluane National Park.

Lepidium densiflorum Schrad. var. *densiflorum*, Common Pepper-grass – YUKON: roadstop in disturbed gravelly soil, Atlin Road just north of BC border, 60°00'09"N 133°47'42.1"W, *Cody & Cody 37543, 37551*, 28 July 2001 (DAO) (determined by G. A. Mulligan).

The specimens cited above are an extension of the known range in the Territory (Cody 1996) of about 125 kilometers southeast of a site just west of Whitehorse.

Lepidium densiflorum Schrad. var. *macrocarpum* G. A. Mulligan – YUKON: adjacent to Catholic Church, Fort Selkirk, 62°46'34.4"N 137°23'35.9"W, *Cody & Kennedy 37808A*, 17 July 2002 (DAO) (determined by G. A. Mulligan).

Cody et al. (2001) reported this variety, which is probably introduced, new to the Territory from the vicinities of Dawson, Ross River and Pelly Crossing. The specimen cited above is an extension of the known range in the Territory of about 50 kilometers to the west of Pelly Crossing.

Parrya arctica R. Br. – Two specimens, one from Pauline Cove, Herschel Island (*Cody 36030*) and the other from the Bonnet Plume River (*Loewen 99-28-93*) were recently revised to *P. nudicaulis* by G. A. Mulligan. These two species can be separated as follows:

A. Stamens linear, 1.5 to 1.75 mm long . . . . *P. nudicaulis*

B. Stamens oblong, less than 1.0 mm long . . . . *P. arctica*

In addition, Cody (1994) reported *P. arctica* from Herschel Island on the basis of a specimen collected by P. F. Cooper (433), 9 May 1979 (CAN) as new to the Territory and suggested that it should be added to the list of rare plants (Douglas et al. 1981). This specimen has now been revised to *Thlaspi arcticum* Porsild by G. A. Mulligan and should be deleted from the flora of Herschel Island and the Yukon Territory.

Rorippa barbareifolia (DC.) Kitagawa – YUKON: Pelly Crossing, 62°51'09"N 136°56'05.2"W, *Cody & Kennedy 37831*, 17 July 2002 (DAO) (determined by G. A. Mulligan).

This species was considered rare in the Territory by Douglas et al. (1981). The specimen cited above is the southernmost yet found adjacent to the Alaska Highway.

Sinapis arvensis L., Charlock – YUKON: in a well-tended flower bed, Haines Junction, *P. Caswell 311*, 5 July 2002 (DAO) (determined by G. A. Mulligan).

The specimen cited above which was the only plant observed in Haines Junction of this introduced species was from only the third site known to Cody (1996) in the Territory.

Subularia aquatica L. ssp. *americana* Mulligan & Calder, Awlwort – YUKON: shallows of large pond east of Alaska Highway north of Sulphur Lake, 61°00.435'N 138°12.729'W, *P. Caswell 772*, 9 Aug. 2002 (DAO) (determined by G. A. Mulligan).

This species was considered rare in the Territory by Douglas et al. (1981). The specimen cited above is an extension of the known range of about 175 kilometers east of a site in the vicinity of Whitehorse (Cody 1996).

Thlaspi arvense L., Penny Cress – in black muck just inside gate, flats 7 miles east of Tagish Bridge, 60°19'5"N 134°10'17"W, *Cody & Cody 37958*, 23 July 2002 (DAO) (determined by G. A. Mulligan).

The specimen cited above is an extension of the known range of this introduced species of about 80 kilometers southeast of the vicinity of Whitehorse.

SAXIFRAGACEAE

Ribes oxyacanthoides L. ssp. *oxyacanthoides* – YUKON: meadow adjacent to RCMP foundation, Fort Selkirk, 62°46'34.4"N 137°23'35.9"W, *Cody & Kennedy 37757*, 16 July 2002 (DAO).

Although quite frequent in the Territory south of latitude 62°N, Cody (1996) knew this shrub from only two sites to the north.

Saxifraga caespitosa L. – YUKON: 40° slope talus dolomite boulders, Mount Casca border Monument 97, 65°21'25"N 141°00'00"W, *B. Bennett & M. Cook 02-515A*, 27 June 2002 (DAO).

Cody (1996) mapped this species in the Territory from three distinct areas (between latitudes 60° and 62°, between latitudes 64° and 66°, and north of latutude 68°. The specimen cited above from adjacent to the Yukon-Alaska border is about 70 kilometers from the sites east and southeast.

Saxifraga eschscholtzii Sternb. – YUKON: dry alpine heath at summit of mountain on Canadian side of Mount Casca, 65°21'37"N 140°59'34"W, *B. Bennett & M. Cook 02-512*, 27 June 2002 (DAO).

Cody (1996) knew this species only from the British Mountains in the extreme northwest of the Territory. The specimen cited above is an extension of the known range in the Territory of about 460 kilometers to the south.

Saxifraga foliolosa R. Br. – YUKON: damp sand of small sandy depression in sedge tundra, ridge south of Donjek Glacier, Kluane National Park, 61°07.383'N 139°31.308'W, *P. Caswell 416*, 8 July 2002 (DAO).

Douglas et al. (1981) considered this species which was known to Cody (1996) from north of latitude 67°N and a single site on the west side of Haines Highway southeast of Haines Junction as rare in the Territory. Cody et al. (2000) reported another site in the south from about 80 kilometers northeast of the site adjacent to the Haines Highway. The specimen cited above is an extension of the range in the south of about 135 kilometers northwest of the site near the Haines Highway.

Saxifraga nelsoniana D. Don ssp. *pacifica* (Hultén) – YUKON: wet organic soil with some fine scree at edge of stream, Tabletop Mountain, Kluane National Park, 61°15.231'N 139°11.115'W, *P. Caswell 285*, 29 June 2002 (DAO).

Douglas et al. (1981) considered this subspecies rare in the Territory. The specimen cited above is an extension of the known range in the Park of about 25 kilometers west of a site west of Kluane Lake.

Saxifraga rufopilosa (Hultén) Porsild – YUKON: moist places in 30° southwest facing large talus dolomite boulders, summit of mountain on Canadian side of Mount Casca, 65°21'37"N 140°59'34"W, *B. Bennett & M. B. Cook 02-528*, 27 June 2002 (DAO).

The specimen cited above is from a site about 35 kilometers northwest of the northernmost site south of latitude 66°N known to Cody (1996).

Saxifraga tricuspidata Rottb., Prickly Saxifrage – YUKON: steep grassy slope on ridge northeast of Woodburn Creek, Tintina Trench, Ddhaw, 63°08'N 136°05'W, *C. E. Kennedy 7*, 27 July 2001 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 100 kilometers east northeast of a site at about longitude 137°W, north of the Pelly River.

ROSACEAE

Amelanchier alnifolia (Nutt.) Nutt., Saskatoon – YUKON: southwest-facing slope across from Brittania Creek, Yukon River, 62°52'28"N 138°42'56"W, *B. Bennett 02-653*, 10 Aug. 2002 (DAO).

Cody (1996) knew only three sites of this species north of the site reported above: Dawson City, Mayo, and adjacent to the Stewart River.

Chamaerhodos erecta (L.) Bge. ssp. *nuttallii* (Pickering ex Rydb.) Hultén – YUKON: common at base of southwest-facing slope, across from Brittania Creek, Yukon River, 62°52'28"N 138°42'56"W, *B. Bennett 02-640*, 10 Aug. 2002 (DAO).

Cody (1996) knew this species in the Territory north to near latitude 64°. The specimen cited above is an extension of the known range in the Territory of about 80 kilometers west of a site adjacent to the Pelly River.

Dryas hookeriana Juz. – YUKON: Ogilvie Mountains, Tombstone Range, Yakamaw Creek, watershed east of Angelcomb Peak, 64°36'N 138°14'W, *Cody 36808, 36845*, 20-22 July 1999 (DAO); *Dryas alaskensis* tundra, Mount Casca border Monument, 65°21'25"N 141°00'00"W, *B. Bennett & M. B. Cook 02-518*, 27 June 2002 (B. Bennett Herbarium, photo DAO).

The specimens cited above are the first yet known to Cody (1996) from west of the Dempster Highway between latitudes 64°N and 66°N.

Geum aleppicum Jacq. ssp. *strictum* (Ait.) Clausen, Yellow Avens – YUKON: Top of the World Golf Course, 64°3'38"N 139°26'13"W, *Cody & Cody 37998*, 25 July 2002 (DAO).

Douglas et al. (1981) considered this taxon rare in the Territory. The specimen cited above is an extension of the known range in the Territory of about 200 kilometers west of a site west of Keno City (Cody et al. 2001) and north of sites adjacent to the Alaska Highway near the Alaska border.

Geum rossii (R. Br.) Scr. – YUKON: moist places at summit of the Canadian side of Mount Casca, 65°21'37"N 140°59'34"W, *B. Bennett 02-524*, 27 June 2002 (B. Bennett Herbarium, photo DAO).

The specimen cited above is from a site about 100 kilometers northwest of the nearest location in the Ogilvie Mountains where it has been collected frequently.

Potentilla arguta Pursh ssp. *convallaria* (Rydb.) Keck, Tall Cinquefoil – YUKON: dry rocky area, South Fork intake, Klondike River, 64°0'30"N 138°12'00"W, *G. Brunner 551*, 22 July 2002 (DAO).

The specimen cited above is only the second collected from north of latitude 64°N in the Territory (Cody 1996). It is from a site about 60 kilometers east of the vicinity of Dawson.

Rosa woodsii Lindl., Western Rose – YUKON: *Artemisia frigida* slope, east side of lake, Whitehorse, Hidden Lakes, 60°41'30"N 135°02'45"W, *B. Bennett 01-118*, 11 July 2001 (B. Bennett Herbarium, photo DAO); grassy alkaline slope north of highway on slope, Alaska Highway Km 1588, 1 km east of Cracker Creek, 60°48'20"N 136°48'00"W, *B. Bennett 02-735*, 11 Sept. 2002 (DAO); common at base of slope, Yukon River, Brittania Creek, 62°52'28"N 138°42'56"W, *B. Bennett 02-639*, 10 Aug. 2002 (B. Bennett Herbarium, photo DAO).

This is a rare species in the Territory (Douglas et al. 1981). The first specimen cited above is only the fourth known in the Territory (Cody 1996). The second is an extension of the known range in the Territory (Cody 1996) of about 50 kilometers west of a site adjacent to the Alaska Highway. The third specimen is an extension of about 125 kilometers northwest of a site reported by Cody et al. (2003) from the vicinity of Carmacks.

FABACEAE (LEGUMINOSAE)

Lupinus nootkatensis Donn – YUKON: clearing between road and poplar forest, west side of Haines Highway, north of cut-off to Dalton Post, 60°09.405'N 136°58.572'W, *P. Caswell 440*, 13 July 2002 (DAO).

The specimen cited above is only the third known from southeastern Kluane National Park and the Yukon Territory.

Oxytropis arctica R. Br., Arctic Oxytrope – YUKON: at base of talus slope, Lower Kathleen Lake, along south shore ca. 25 km SE of Haines Junction, 60°33'N 137°16'W, *G. W. & G. G. Douglas 8391*, 25 June 1975 (Kluane National Park, photo DAO); in alpine fell field, Dezadeash River Valley ca. 16 km WSW of Haines Junction, *G.W. & G.G. Douglas 8405*, 30 June 1975 (Kluane National Park Herbarium, photo DAO).

Cody (1996) suggested that this species should be looked for in the mountains of northern Yukon Territory because it is known in the Canadian Arctic and northern Alaska. Douglas et al. (1999) included the Territory in the distribution of *O. arctica* presumably on the basis of the specimens cited above and also reported the only collection known in British Columbia from Mile 416 Alaska Highway which is about 700 kilometers east southeast of the Yukon sites. It should be added to the list of rare species in the Territory.

Oxytropis campestris (L.) DC. ssp. *varians* (Rydb.) Cody, Field Locoweed – YUKON: steep grassy slope on ridge northeast of Woodburn Creek, Tintina Trench, Ddhaw Ghro, 63°08'N 136°05'W, *C. E. Kennedy 6*, 27 July 2001 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 110 kilometers northeast of a site adjacent to the Yukon River.

Trifolium pratense L., Red Clover – YUKON: roadside, junction of Campbell Highway and Frenchman Lake Road, 62°4'30"N 135°30'55"W, *Cody & Cody 37985*, 24 July 2002 (DAO).

The nearest site of this introduced species in the Territory (Cody 1996) is from the vicinity of Whitehorse, about 150 kilometers to the south.

Vicia americana Muhl., American Vetch – YUKON: border of grassland and *Populus*, Macoobs Park, Mayo, 63°35'42.5"N 135°56'57.1"W, *Cody & Cody 37668*, 5 Aug. 2001 (DAO); west end of parking lot by visitor kiosk, Rancheria, 60°05'16"N 130°36'10"W, *B. Bennett 01-059*, 26 July 2001 (DAO).

Douglas et al. (1981) considered this species rare in the Territory on the basis of a single collection from the Larsen Creek hotsprings in the extreme southeast (Scotter & Cody 1979). Additional collections were added from this area by Cody et al. (1998) and from the vicinity of Watson Lake (Cody et al. 2000). The first specimen cited above is an extension of the known range in the Territory of about 550 kilometers to the northwest of Watson Lake. The second collection is an extension of the known distribution of about 120 kilometers west of Watson Lake but was probably introduced at that site.

CALLITRICHACEAE

Callitriche anceps Fern. – YUKON: on mud substrate at edge of water, old beaver pond east of Haines Highway about 10 kilometers south of Kathleen Lake cutoff, 60°30.838'N 137°04.970'W, *P. Caswell 787*, 11 Aug. 2002 (DAO).

This species was considered rare in the Territory (Douglas et al. 1981). The specimen cited above is from a site about 30 kilometers northwest of a site in Kluane National Park.

VIOLACEAE

Viola renifolia Gray var. *brainerdii* (Greene) Fern., Kidney-leaved Violet – YUKON: humus covered with old poplar leaves, poplar and white spruce wood flat, Wade Lakes Road, between Kluane National Park and Haines Highway, 60°07.119'N 137°05.369'W, *P. Caswell 020*, 6 June 2002 (DAO).

Cody (1996) knew this species as far north as the vicinity of Dawson City. The specimen cited above is an extension of the known range in the Territory of about 150 kilometers southwest of the vicinity of Whitehorse.

HALORAGACEAE

Myriophyllum verticillatum L. – YUKON: in water beside dock, Nunatuk Camp, 62°9'49"N 135°48'4"W, *Cody & Cody 37989*, 24 July 2002 (DAO).

Douglas et al. (1981) considered this species rare in the Territory. The specimen cited above is from a site about half way between the Pelly River and the north end of Lake Lebarge.

APIACEAE

Cicuta maculata L. var. *angustifolia* Hook., Spotted Water-hemlock – YUKON: lush herbaceous meadow on riverbank, Kirkman Creek, Yukon River, 62°59'21"N 139°23'07"W, *B. Bennett 02-284*, 10 Aug. 2002 (DAO).

Douglas et al. (1981) considered this taxon rare in the Territory. The specimen cited above is an extension of the known range of about 175 kilometers to the northwest of Carcross (Cody 1996).

Podistera macounii (Coult. & Rose) Mathias & Const. – YUKON: *Dryas alaskensis* tundra, Mount Casca bor-

der Monument 97, 65°21'25"N 141°00'00"W, *Bennett & Cook 02-520*, 27 June 2002 (DAO).

This species was considered rare in the Territory by Douglas et al. (1981). Cody (1996) knew it only from the Richardson Mountains area in the northeast. Cody et al. (1998) extended the known range in the Territory south into the Dawson range at latitude 62°26'N. The specimen cited above is an extension of the known range in the Territory of about 275 kilometers to the west from the southernmost site in the Richardson Mountains.

PYROLACEAE

Pyrola minor L. – YUKON: adjacent to the Catholic Church, Fort Selkirk, 62°46'34.4"N 137°23'35.9"W, *Cody & Kennedy 37815*, 17 July 2002 (DAO).

Although quite frequent in the Territory east and north of the Klondike Highway, Cody (1996) also knew this species from the vicinity of southern Kluane Lake, to the west.

ERICACEAE

Cassiope tetragona (L.) D. Don ssp. *saximontana* (Small) Porsild – YUKON: dry alpine *Dryas* heath, summit of Mount Casca, 65°21'37"N 140°59'34"W, *Bennett & Cook 02-522*, 27 June 2002 (DAO).

The specimen cited above is the northernmost yet found in the Territory. The nearest site to the above north of Chapman Lake in the Ogilvie Mountains is about 125 kilometers to the southeast (Cody et al. 2001).

Harrimanella stellariana (Pallas) Coville – YUKON: Morley River watershed, Englishman Range, 8 km SW of Morris Lake, northwest facing slope growing in bedrock controlled draw, 60°23'40"N 131°47'50"W, *J. Meikle 02-126*, 20 June 2002 (DAO).

The specimen cited above is a rarity in the Territory (Douglas et al. 1981). It is a slight range extension north of the eastern site mapped by Cody (1996).

Phyllodoce glanduliflora (Hook). Cov., Yellow Mountain-heather – YUKON: subalpine slope by creek, Tank Creek, 60°05'30"N 134°41.9'W, *S. Withers SW01-114*, 15 July 2001 (DAO).

Cody (1996) knew this species in the Territory only from sites east of longitude 130°W and west of longitude 137°W. The specimen cited above is about 125 kilometers east of a site in Kluane National Park.

Vaccinium membranaceum Dougl., Tall Blueberry – YUKON: moist subalpine meadow, Kotaneelee Range, 60°14'31"N 124°7'19"W, *B. Bennett 98-149*, 20 June 1998 (B. Bennett Herbarium, photo DAO); subalpine forest, Beavercrow Ridge, 60°12.865'N 124°35.79'W, *B. Bennett 98-310*, (B. Bennett Herbarium, photo DAO).

Cody (1996) suggested that this species should be looked for in the southeastern part of the Territory. Cody et al. (1998) reported four collections from Mount Merrill and Gusty Lakes. The two specimens cited above are from the extreme southeast.

PRIMULACEAE

Douglasia alaskana (Cov. & Standl.) Kelso – YUKON: eroded alpine slope, Table Mountain, Kluane National Park, 61°15'.231'N 139°11.115'W, *P. Caswell 282*, 29 June 2002 (DAO).

Douglas et al. (1981) considered this species rare in the Territory where it was only known in Kluane National Park. The specimen cited above extends the known range in the Park about 75 kilometers to the northwest.

Douglasia arctica Hook. – YUKON: Cody et al. (2000) reported this species from a mountain between Kusawa and JoJo Lake, which was a considerable southward range extension.

The specimen upon which it was reported was unfortunately misidentified and the range extension should be deleted.

Primula eximia Greene (*P. tschuktschorum* Kjellm. ssp. *cairnesiana* A. E. Porsild) – YUKON: Dempster Highway about Km 96, at about altitude 4000 ft., *S. Frisch*, spring 2001 (DAO).

Douglas et al. (1981) considered this species rare in the Territory on the basis of collections from the northern Richardson Mountains and a site adjacent to the Alaska border at about 63°50'N latitude. The specimen cited above is from a site about 150 kilometers northeast of the Alaska border site where there was "a whole field of them".

Trientalis europaea L. s.l., Starflower – YUKON: damp mossy *Picea glauca*, *Alnus incana*, Dawson area, 64°02'00"N 137°41'30"W, *G. Brunner 439*, 30 June 2001 (DAO).

The specimen cited above from about 70 kilometers east of Dawson City, is only the second collection in the Territory from north of latitude 64°N (Cody 1996).

GENTIANACEAE

Gentianella tenella (Rottb.) Boerner – YUKON: alpine barrens on long ridge, Atlas Mountain, Kluane National Park, 61°14.772'N 139°19.254'W, *D. Normandeau* s.n., *P. Caswell 328A*, 6 July 2002 (DAO); patch of alpine tundra, mountain opposite Donjek Glacier, Kluane National Park, 61°11.859'N 139°23.372'W, *P. Caswell 619*, 26 July 2002 (DAO).

This species was considered rare in the Territory by Douglas et al. (1981). Cody (1996) knew it from only three sites, two about 40 kilometers west of the specimens cited above and one just north of latitude 62°N.

POLEMONIACEAE

Phlox hoodii Richards., Moss Phlox – YUKON: dry rocky slope, open habitat, Donjek River watershed near Kluane Glacier, *M. Hoefs 02-693*, 4 July 2002 (DAO).

The specimen cited above from west of the Alaska Highway is the fifth and southernmost in that area. This species was not included in the *Rare Vascular Plants of the Yukon* (Douglas et al. 1981) because of its widespread distribution.

Polemonium acutiflorum Willd. forma *lacteum* Lepage – YUKON: rare in lush subalpine meadow at 4800 ft., mountain 4 miles west of Upper Hyland Lake, 62°03'N 128°59'W, *Calder & Kukkonen 27889*, 3 Aug. 1960 (DAO) (determined by B. Boivin 1970).

Lepage (1950) described this white-flowered form on the basis of a specimen collected at Anchorage, Alaska. Cody (1996) unfortunately did not mention this white form occurring in the Yukon Flora.

Polemonium boreale Adams *forma albiflorum* Cody, – YUKON: fox den, sandy/grass area, Herschel Island, site 203, 69°30'N 139°15'W, *C. E. Kennedy 262*, 16 July 1985 (DAO) (PARATYPE); [NORTHWEST TERRITORIES: MACKENZIE: on a sandy portion of a gravel bar, Horton River, N.W.T., 69°42'N 126°56'W, *G. W. Scotter 101016b*, 6 July 1995 (DAO) (HOLOTYPE) (Cody et al. 2003).

Cody (1996) stated that the corolla of this species was blue to violet or rarely white. The white form had not been described at that time.

HYDROPHYLLACEAE

Phacelia mollis Macb., Macbryde's Phacelia – YUKON: scattered in dry, open rubble on south-facing slopes near base of bluff, Moosehide Hills, Bluff on N side of Yukon R., 25 km downstream from Dawson, 64°15'41"N 139°36'13"W, *C. Roland 93-27*, 24 May 1993 (AKA, photo DAO).

The specimen cited above is an extension of about 50 kilometers to the southwest from the nearest site in the Ogilvie Mountains known to Cody (1996).

BORAGINACEAE

Eritrichium aretioides (Cham. & Schlecht.) DC. – YUKON: dry alpine *Dryas* heath, Canada/US Boundary Monument 97, 65°21'25"N 141°00'00"W, *B. Bennett 02-019*, 27 June 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 40 kilometers northwest of the nearest site known to Cody (1996) between latitudes 64° and 66°N.

Eritrichium chamissonis DC. – YUKON: vicinity of Snowdrift Camp, Vuntut National Park, 68°21.4'N 139°13.1'W, *P. Caswell PPC-Y-076*, 19 June 2000 (B. Bennett Herbarium, photo DAO).

Cody (1996) knew this rare species in the Territory from only two localities in the British Mountains. The specimen cited above is from a site about 50 kilometers south of a site on Mt. Sedgwick.

Mertensia paniculata (Britt.) G. Don var. *alaskana* (Britt.) Williams – YUKON: adjacent to Joe Robert's Cabin, Fort Selkirk, 62°46'34.4"N 137°23'35.9"W, *Cody & Kennedy 37796*, 17 July 2002 (DAO).

Cody (1996) knew this variety only from south of latitude 61°30'N and north of latitude 67°30'N.

Myosotis scorpioides L., Forget-me-not – YUKON: flower bed at Kluane Park Inn, Haines Junction, 60°44'N 137°31'W, *P. Caswell PPC-2000-Y-426*, 28 Aug. 2000 (B. Bennett Herbarium, photo DAO).

This introduced species was previously known in the Territory only from the vicinity of Whitehorse (Cody 1996).

LAMIACEAE (LABIATAE)

Galeopsis tetrahit L. ssp. *bifida* (Boenn.) Fries, Hempnettle – YUKON: Forty Mile Historic Site at the confluence of the Forty Mile and Yukon rivers, 64°25'N 140°32'W, *C. E. Kennedy 2*, 6 July 2000 (DAO); under large *Picea glauca* in squirrel midden, Judas Creek, 60°23.4'N 134°07.4'W, *S. Withers SW01-178*, 30 Aug. 2001 (B. Bennett Herbarium, photo DAO).

This introduced species was previously known in the Territory from only three localities: North Canol Road (Cody 1994, 1996), Km 9 Dempster Highway (Cody et al. 1998) and Whitehorse (Cody et al. 2001). The first specimen cited above is the northernmost yet found in the Territory.

SCROPHULARIACEAE

Euphrasia subarctica Raup – YUKON: stony soil and moss in cleared area below rest stop, Klondike Highway Km 628, 63°50'18.1"N 137°59'20.5"W, *Cody & Cody 37660*, 4 Aug. 2001 (DAO).

The specimen cited above is the northernmost yet found in the Territory (Cody 1996). It is from a site about 110 kilometers northwest/west of Mayo.

Mimulus guttatus DC., Yellow Monkeyflower – YUKON: small seep near the road, Km 4.5 Atlin Road, 60°17'30"N 133°50'3"W, *S. Withers SW01-131*, 24 July 2001 (DAO).

Douglas et al. (1981) considered this species rare in the Territory. The specimen cited above is from a site about 80 kilometers southeast of Whitehorse.

Pedicularis oederi Vahl., Oeder's Lousewort – YUKON: Herschel Island, 69°35'N 139°05'W, *C. E. Kennedy s.n.*, 30 July 1985 (Yukon Renewable Government Herbarium, photo DAO).

This species, which is frequent in the British Mountains to the south is now known to the north on Herschel Island.

Rhinanathus minor L. ssp. borealis (Sterneck) A. Löve – Yukon: gravel parking area at foot of trail to Rock Glacier, Haines Highway, 60°27'18"N 137°03'37.6"W, *Cody & Cody 37894*, 21 July 2002 (DAO).

This taxon is known in the Territory only as far north as about latitude 61°30'N. The specimen cited above is the first record from the Haines Highway.

OROBANCHACEAE

Orobanche fasciculata Nutt. – YUKON: 45° silty sand south-facing slope with *Artemisia frigida* and *Calamagrostis purpurascens*, Dutch Bluff, Yukon River, 61°55.72'N 135°03.99'W, *B. Bennett 02-290*, 7 Aug. 2002 (DAO).

This species was considered rare in the Territory by Douglas et al. (1981). Cody et al. (2003) reported a new site in Kluane National Park adjacent to the Alaska Highway and southern Kluane Lake. The specimen cited above is from a site about 50 kilometers southeast of Carmacks.

LENTIBULARIACEAE

Pinguicula villosa L. – YUKON: in *Sphagnum* tussock, bog east of Haines Highway, 60°08.421'N 136°58.499'W, *P. Caswell 446*, 13 July 2002 (DAO).

The specimen cited above is new to southwestern Yukon. It is an extension of the known range in the Territory of about 300 kilometers southwest from a site adjacent to the northern South Canol Road.

Utricularia minor L., Lesser Bladderwort – YUKON: shallow water of lake between Ross River and Campbell Highway, 61°58'16"N 132°38'06"W, *Cody & Cody 37967*, 24 July 2002 (DAO).

This is a rare species in the Territory that Cody (1996) knew from only four sites between latitudes 60°N and 64°30'N.

Cody et al. (1998, 2000 and 2003) reported new collections from the southeast in the vicinity of La Biche River and in the far north between Trout Lake and the Babbage River. The specimen cited above is from about 150 kilometers north of a site near the south end of the South Canol Road.

PLANTAGINACEAE

Plantago canescens Adams – YUKON: base of cliffs, talus, south-facing slope, Mount Carmacks, 64°20'08"N 140°12'25"W, *B. Bennett 02-820*, 24 Aug. 2002 (DAO).

The specimen cited above is an extension of the known range in the Territory of about 200 kilometers northwest of a site adjacent to the Klondike Highway (Cody 1996).

Plantago maritima L., Seaside Plaintain – YUKON: dry sandy gravel slope north of gravel pit south of Alaska Highway, 60°49'58"N 135°45'49"W, *Cody & Cody 38204*, 1 Aug. 2002 (DAO).

This species was considered rare in the Yukon Territory by Douglas et al. (1981). Cody (1996) knew it from only two localities adjacent to Kluane Lake in the extreme southwest. The specimen cited above is from a site about 100 kilometers to the east.

CAPRIFOLIACEAE

Sambucus racemosa L. ssp. *pubens* (Michx.) House, Red Elderberry – YUKON: roadside and lakeshore, Wade Lakes, 60°05.0'N 137°19.6'W, *R. Maraj s.n.*, 14 Sept. 2002 (DAO).

Douglas et al. (1981) (as var. *arborescens*) knew this taxon from a single locality in southern Kluane National Park. The specimen cited above extends the known range about 80 kilometers to the east between the park and Haines Highway.

VALERIANACEAE

Valeriana sitchensis Bong., Sitka Valerian – YUKON: Site YPN 120, 63°06'39.8"N 133°20'15"W, *G. Brunner 569-01*, 6 Aug. 2001 (Environment Yukon, photo DAO).

The specimen cited above is from a site between the North Canol Road and Mayo.

ASTERACEAE (COMPOSITAE)

Aster alpinus L. ssp. *vierhapperi* Onno, Alpine Aster – YUKON: steep grassy slope on ridge, northeast of Woodburn Creek, Tintina Trench, Ddhaw Ghro, 63°08'N 136°05'W, *C. E. Kennedy 2*, 27 July 2001 (DAO).

The specimen cited above is an extension of the known range in the Territory (Cody 1996) of about 100 kilometers northeast of a site near the junction of the Pelly and Yukon rivers.

Aster falcatus Lindl., Western Heath Aster – YUKON: lush herbaceous meadow riverbank, Kirkman Creek, Yukon River, 62°59'21"N 139°23'07"W, *B. Bennett 02-673*, 10 Aug. 2002 (B. Bennett Herbarium, photo DAO).

Douglas et al. (1981) considered this species rare in the Territory. The specimen cited above is from a site about 150 kilometers west of a site adjacent to the Klondike Highway.

Erigeron caespitosus Nutt. – YUKON: silty sand south-facing slope, Dutch Bluff, Yukon River, 61°55.72'N 135°03.99'W, *B. Bennett 02-300*, 7 Aug. 2002 (DAO); top of slope of open bank, 1 mile upstream of Big Salmon, on Yukon River, 61°51.41'N 134°55.01'W, *B. Bennett 02-302*, 7 Aug. 2002 (DAO); base of cliffs, talus, south-facing slope, Yukon River, Mount Carmacks, 64°20'08"N 140°12'25"W, *B. Bennett & R. Mulder 02-816*, 24 Aug. 2002 (DAO).

The first specimen cited above is from a site about 75 kilometers southeast of a site adjacent to Carmacks and the second specimen is from a site about 120 kilometers southeast of Carmacks. The third specimen is from a site between two sites near the Alaska border, one to the south about 120 kilometers and the other to the north about 100 kilometers (Cody 1996).

Erigeron hyperboreus Greene – YUKON: middle of dirt road leading to Copper Joe Creek Road, Kluane National Park, 61°18.688'N 138°56.319'W, *P. Caswell 170*, 24 June 2002 (DAO).

This species was considered as rare in the Territory by Douglas et al. (1981). The specimen cited above is an extension of about 425 kilometers south of a site northwest of Dawson City.

Senecio eremophilus Richards., Dryland Ragwort (Figure 6) – YUKON: Pine Creek Campground, 4 miles east of Haines Junction, Mile 1012 Alaska Highway, *V. L. Harms 6299*, 17 August 1968 (DAO).

The specimen cited above is the first known record in the Yukon Territory where it was probably introduced. To the

FIGURE 6. *Senecio eremophilus,* Dryland Ragwort (drawn by J. Looman).

west in Alaska, Hultén (1968) knew it only from the vicinity of Tok where he considered it also to be introduced. To the east Porsild and Cody (1980) knew it from the Slave River area north of Fort Smith where it was found in damp woodland meadows and adjacent to roadsides and considered native. To the south it is found in eastern British Columbia east to Manitoba and south into the United States. It can be separated from *S. sheldonensis* as follows:

A. Stem leaves deeply incised, not reduced upwards .... *S. eremophylus*

B. Stem leaves with merely repand-denticulate margins, reduced upwards .... *S. sheldonensis*

Solidago canadensis L. var. *salebrosa* (Piper) Jones – YUKON: beside test plot, 1 km N of Montague Roadhouse, Km 132 Klondike Highway, 61°49'35"N 136°7'52"W, *Cody & Cody 38073*, 28 July 2002 (DAO).

Douglas et al. (1981) considered this species rare in the Territory. The specimen cited above is from about 90 kilometers southwest of a site mapped by Cody (1996).

Sonchus arvensis L. ssp. *uliginosus* (Bieb.) Nyman, Perennial Sow-thistle – YUKON: roadside gravel, Alaska Highway 3 km west of Kusawa Lake turnoff below microwave tower, 60°46'00"N 136°05'36"W, *B. Bennett 02-749*, 11 Sept. 2002 (DAO).

The specimen of this introduced species cited above is from a site between Whitehorse and Haines Junction.

Tanacetum vulgare L., Common Tansey – YUKON: in distributed ground along Campbell Highway, Tuchitua River, 60°56'N 129°13'00"W, *R. Rosie 1959*, 16 Aug. 1997 (DAO); single patch west of the boat launch, Yukon River Bridge, 60°34'20"N 134°40'W, *B. Bennett 01-063*, 19 Aug. 2001 (DAO).

The specimens cited above are only the second and third records of this introduced species in the Territory. Cody et al. (1998) reported the first collection from just north of Kathleen Lake Lodge on the Haines Highway.

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Hybridization Between a Green Turtle, *Chelonia mydas,* and Loggerhead Turtle, *Caretta caretta*, and the First Record of a Green Turtle in Atlantic Canada

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The Green Turtle (*Chelonia mydas*) principally occupies tropical and subtropical waters, although juveniles are known to occur seasonally in temperate coastal waters. Collaboration with commercial fishers in eastern Canada yielded the most northerly records of this species in the northwest Atlantic. Here we report on the first confirmed record of a Green Turtle in eastern Canada and on the occurrence of a rare Green Turtle–Loggerhead Turtle (*Caretta caretta*) hybrid. Hybridization between the Carettini and Chelonini is extraordinary given that these groups have been genetically distinct for 50 million years or more.

Key Words: Green turtle, *Chelonia mydas*, hybrid, Loggerhead Turtle, *Caretta caretta*, Atlantic Canada.

The Green Turtle (*Chelonia mydas*) has a broad range in the Atlantic, which includes waters off the continental United States. Presence in temperate waters of the northeastern United States is seasonal, with turtles retreating to more southerly latitudes when water temperatures decline (Epperly et al. 1995). During summer and fall, this species regularly occurs as far north as New York (Morreale et al. 1992); however, records of Green Turtles at higher latitudes of the United States are rare. While both Leatherback Turtles (*Dermochelys coriacea*) and Loggerhead Turtles (*Caretta caretta*) are commonly encountered in waters off Atlantic Canada (e.g., Bleakney 1965), with leatherbacks occupying both nearshore and offshore waters (James et al. 2005) and loggerheads mainly offshore waters, there were no previous confirmed reports of the Green Turtle in this region. Here we report on photo-documented records of a Green Turtle and a Green Turtle-Loggerhead Turtle hybrid in nearshore waters off Nova Scotia, Canada. These exist as the most northerly confirmed records of *Chelonia mydas* in the northwest Atlantic.

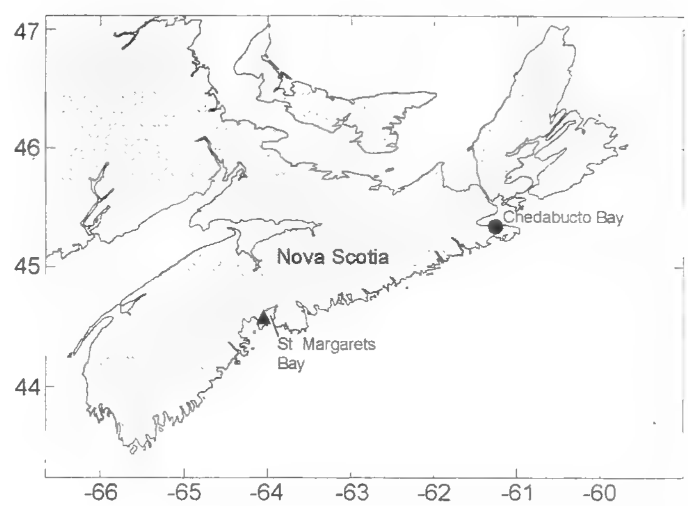

FIGURE 1. Capture locations of juvenile Green Turtle (solid circle) and juvenile Green Turtle × Loggerhead Turtle hybrid (solid triangle).

Notification about both turtles initially came through calls to a toll-free phone line established for fishing community members in Atlantic Canada to report sea turtle sightings (Martin and James 2005). A small, live cheloniid turtle was reported on 8 August 1999. The turtle was found in Chedabucto Bay, Nova Scotia (at 45°20'37"N, 61°15'36"W, Figure 1) and was photographed and released shortly before the call was placed. The turtle was not measured; however, curved carapace length (CCL) was estimated to be between 30 and 40 cm and its mass approximately 4-5 kg. Species identification was confirmed as *C. mydas* (juvenile) upon receipt of several excellent photographs that depicted carapacial scute configuration and scale patterning on the head (Figure 2).

The second turtle, also live, was reported on 2 October 2001. It was found in St. Margarets Bay, Nova Scotia (at 44°34'56"N, 64°03'06"W, Figure 1). The animal

FIGURE 2. Juvenile Green Turtle (*Chelonia mydas*) found in Chedabucto Bay, Nova Scotia, on 8 August 1999.

was considered unusual by the inshore commercial fishers who encountered it because they had never seen a cheloniid turtle before. Therefore, they collected it and brought it to shore for examination.

One of us (MCJ) responded to the report and examined the turtle (CCL 34 cm; mass 4.07 kg), tentatively identifying it as a juvenile *C. mydas*. The plastron of the turtle was cream coloured, the cutting edge of the lower tomium was mildly serrated, and it had a pair of large prefrontal scutes on its head (Figure 3), all features characteristic of a Green Turtle. However, while the number and arrangement of carapacial scutes was consistent with those of a Green Turtle, there were two claws on the anterior margin of each front flipper, the costal and vertebral scutes overlapped considerably, and the marginal scutes were strongly serrated (Figure 3), which suggested that the turtle was possibly a hybrid.

At the time of examination, the turtle's movements were sluggish and it was judged to be mildly hypothermic. Small juvenile cheloniid turtles foraging in coastal areas of the temperate north Atlantic in the fall are particularly vulnerable to developing hypothermia, as water temperatures can rapidly drop below 20°C (Davenport 1997). This animal was recovered from an area where the sea surface temperature was 16.2°C. Given the turtle's compromised physical condition and the declining water temperatures along the coast of Nova Scotia, the turtle was moved to the animal care facilities at Dalhousie University in Halifax, where it was warmed and rehydrated for approximately 60 hours in a freshwater bath at 24°C. It was then transported south by air on the evening of 4 October 2001 for release in Bermudian waters.

Subsequent genetic analysis at the U.S. National Marine Fisheries Laboratory in La Jolla, California, confirmed that this turtle was a hybrid. This was determined by sequencing a 391 bp fragment of the control region of mitochondrial DNA (mtDNA) extracted from a blood sample (Dutton 1996). The results revealed that this turtle had Loggerhead Turtle mtDNA, while phenotypically it was principally a Green Turtle. Since mtDNA is maternally inherited, we conclude that this animal was the progeny of a female Loggerhead Turtle and a male Green Turtle.

Discussion

The extent to which natural hybridization in sea turtles occurs has not been determined. However, as genetic techniques like the ones employed here are increasingly applied, hybridization may prove to be more common than previously thought. Molecular genetics have confirmed hybridization between the Loggerhead Turtle and Kemp's Ridley Turtle (*Lepidochelys kempii*) (Karl et al. 1995; Barber et al. 2003), Loggerhead Turtle and Hawksbill Turtle (*Eretmochelys imbricata*) (Karl et al. 1995; Witzell and Schmid 2003), and Green Turtle and Hawksbill Turtle (Wood et al. 1983; Karl

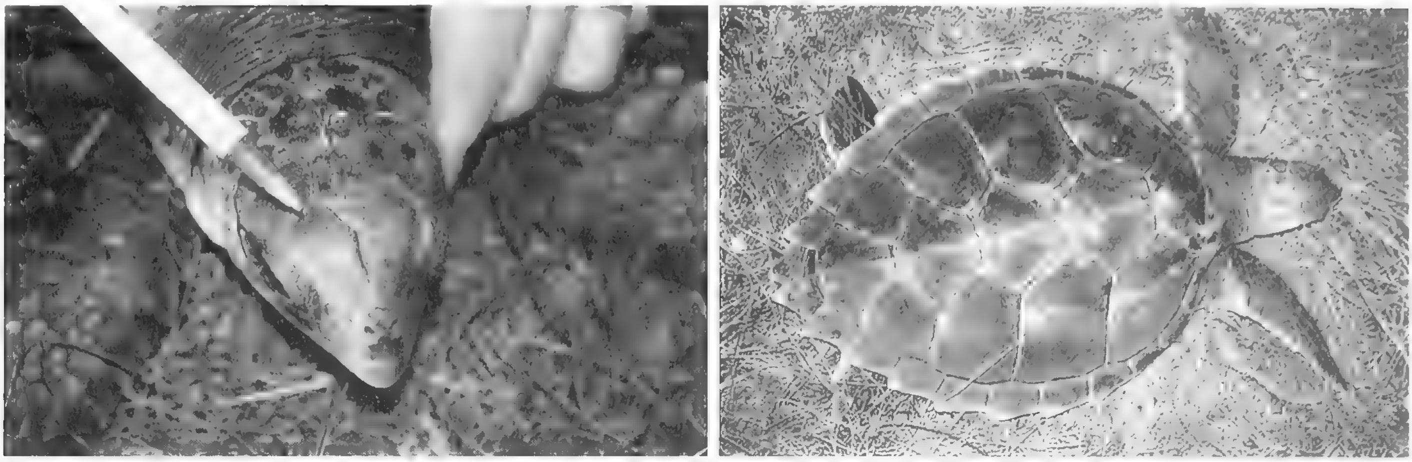

FIGURE 3. Green Turtle-Loggerhead Turtle hybrid found in St. Margarets Bay, Nova Scotia, on 2 October 2001. The large pair of prefrontal scutes on the head (left) are characteristic of *Chelonia mydas*. However, overlapping costal and vertebral scutes and strongly serrated marginal scutes (right) are not characteristic of *Chelonia mydas*.

et al. 1995). In addition to the results presented here, there is only one previous report of hybridization between a Loggerhead Turtle and a Green Turtle (Karl et al. 1995). Hybridization between the Carettini and Chelonini is extraordinary given that these tribes have been genetically separated for 50 million years or more (Bowen et al. 1993; Dutton et al. 1996). It has been suggested that these may be the oldest vertebrate lineages known to hybridize in nature (Karl et al. 1995).

The reproductive status of marine turtle hybrids is not known; however, the identification of potential second-generation hybrids (Karl et al. 1995) suggests that at least some hybrids may be fertile. Reproductive viability in hybrids could have important biological consequences for the conservation of marine turtles (Karl 1996).

Both turtles reported here were of the size class typical of neritic foraging populations of Green Turtles (i.e., straight carapace length >25 cm) (Musick and Limpus 1997). Therefore, these animals likely arrived in eastern Canadian waters from coastal foraging habitat off the northeastern United States, rather than from pelagic areas.

Our current understanding of juvenile Green Turtle distribution in the northwest Atlantic suggests that these turtles occupy areas where sea surface temperature is normally higher than that of coastal Atlantic Canada. In the case of the hybrid turtle, the Loggerhead Turtle component of its genotype may have been responsible for directing the animal to higher latitudes for foraging, as Loggerhead Turtles are commonly encountered in Atlantic Canadian offshore waters. However, the animal's presence in nearshore waters off Nova Scotia remains puzzling. Loggerhead Turtles are rarely encountered in coastal areas of Atlantic Canada because sea surface temperatures are normally at or below the lower thermal tolerance limits of this species.

There was no formal attempt in eastern Canada to specifically promote the reporting of marine turtle sightings until 1998, when a broad public education program and toll-free reporting line were established for this purpose (Martin and James 2005). Continued collaboration with commercial fishers will be key to determining if the records reported here represent accidental occurrences of the Green Turtle in this region, or if small numbers of this species regularly forage along the Scotian Shelf in summer and early fall when inshore water temperatures are highest.

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A Snow-tracking Protocol Used to Delineate Local Lynx, *Lynx canadensis*, Distributions

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Determining Canada Lynx (*Lynx canadensis)* distribution is an important management need, especially at the southern extent of the species range where it is listed as *threatened* under the U. S. Endangered Species Act. We describe a systematic snow-track based sampling framework that provides reliable distribution data for Canada Lynx. We used computer simulations to evaluate protocol efficacy. Based on these simulations, the probability of detecting lynx tracks during a single visit (8 km transect) to a survey unit ranged from approximately 0.23 for surveys conducted only one day after snowfall, to 0.78 for surveys conducted 7 days after a snowfall. If the survey effort was increased to three visits, then detection probabilities increased substantially from 0.58 for one day after snowfall to about 0.95 for surveys conducted 7 days after a snowfall. We tested the protocol in the Garnet Range, Montana, where most lynx were radio-collared. We documented a total of 189 lynx tracks during two winters (2001-2003). Lynx distribution based on snow-track surveys was coincident with the area defined through radio telemetry. Additionally, we conducted snow-track surveys in areas of western Wyoming where lynx were believed present but scarce. We detected a total of six lynx tracks during three winters (1999-2002). In Wyoming , where lynx presence was inferred from a few tracks, we verified species identification by securing genetic samples (hairs from daybeds) along track-lines.

Key Words: distribution, forest carnivore, Canada Lynx, *Lynx canadensis*, snow-track, Montana, Wyoming, surveys.

Listing Canada Lynx (*Lynx canadensis*) as "Threatened" in the U. S. under the Endangered Species Act compels land managers to consult with the U.S. Fish and Wildlife Service regarding potential impacts of management actions (Federal Register, Volume 63, Number 130). One of the most fundamental information needs is to delineate the current distribution of lynx in the contiguous United States. Definitive range determination for rare and elusive carnivores, like the lynx, is difficult and may require several well-tested survey methods. The National Lynx Survey uses hair-collection pads (McDaniel et al. 2000) as a means of detection over large areas including much of the northern and western portions of the United States (K. S. McKelvey). DNA analysis of collected hair provides positive species identification (Mills et al. 2000), and is the only tested detection method during non-snow periods for lynx. However, unless multiple samples are obtained from a site, the method cannot distinguish local populations from single dispersing individuals, an important issue for land managers.

Snow-tracking provides a survey method for detecting lynx during the winter (Halfpenny et al. 1995; Zielinski and Kucera 1995). Unlike hair-pad surveys, snow track surveys do not require a behavioral response, like rubbing, for detection. Lynx also have many attributes that make them particularly good candidates for snow-track surveys: lynx from southern populations have large spatial-use areas (approximately 150 km^2 for males and 70 km^2 for females; Aubry et al. 2000); have high daily travel rates (Ward and Krebs 1985; Mowat et al. 2000); and a distinctive snow-track that facilitates identification (Halfpenny and Biesiot 1986; Forrest 1988). Snow-tracking also provides anecdotal information, such as identification of family groups, useful for distinguishing local populations from dispersing individuals.

Snow tracking has been used extensively to survey lynx and other forest carnivores (Thompson et al. 1989; Stephenson and Karczmarczyk 1989; Beier and Cunningham 1996; Becker et al. 1999), but, like other detection techniques, snow-track surveys have inherent strengths and weaknesses. Snow track surveys can be conducted across extensive landscapes at reasonable costs, and the method is sensitive to changes in carnivore occupancy. However, potential problems with snow-track surveys include track misidentification and difficulties in achieving representative surveys (Halfpenny et al. 1995; Zielinski and Kucera 1995). For example, Aubry and Lewis (2003) found that unscreened records of Fishers (*Martes pennanti*) that presumably included many "false positives" yielded a different, and much more extensive, distribution when compared to verified records. Misidentifications can also have serious management impacts if the detected species is listed as Threatened or Endangered under the U. S. Endangered Species Act.

Here, we describe and evaluate a track-based survey method for lynx and its potential limitations. Our goal was to develop a reliable and representative winter survey method to complement existing summer surveys. Specifically, we needed to improve on existing snow-

track survey methodologies to ensure they are representative in terms of their spatial extent and habitat coverage, and to address problems of track misidentification by incorporating genetic sampling (i.e., scats and hairs frozen in tracks and daybeds). To evaluate reliability we tested these methods both through computer simulation and through direct comparisons with radio-telemetry data in an area where most lynx were radio-collared.

Study Areas

We conducted lynx surveys in the Garnet Mountain Range of western Montana, and in the Wyoming/Salt River Mountains approximately 80 km southwest of Jackson, Wyoming. Approximately 80% of the Garnet Range is forested within the Douglas-fir (*Pseudotsuga menziesii)* and Subalpine Fir (*Abies lasiocarpa)* series of the Montana Forest Habitat type (Pfister et al. 1977; Burcham et al. 1999). Dominant tree species include Subalpine Fir, Engelmann Spruce (*Picea engelmannii),* Lodgepole Pine (*Pinus contorta)*, and Douglas-fir. Elevations range from 1160 to 2090 m. The primary use of forested public and private lands is timber management, and much of the area was extensively logged within the past 25 years. The Garnet Range is adjacent to private lands that consist mainly of irrigated hay fields and Big Sage Brush (*Artemisia tridentata)* – wheat grass (*Agropyron* spp.) cover types.

The Wyoming and Salt River ranges, located in west-central Wyoming, support mixed conifer forests that include Subalpine Fir, Engelmann Spruce, Lodgepole Pine, Whitebark Pine (*Pinus albicaulis)*, Douglas-fir, and Quaking Aspen *(Populus tremuloides).* Mesic sites are dominated by Subalpine fir and Engelmann Spruce forests in seasonally moist or wet areas, or where subirrigation maintains a high water table. Spruce-fir forests are typically co-dominant with Lodgepole Pine. Dry sites are dominated by Lodgepole Pine forests, often intermixed with Douglas-fir and Quaking Aspen. Precipitation is mostly in the form of snow; elevations range from 1981 – 3353 m.

Methods

Modeling Track Detections

We estimated the probability of detection relative to search effort using computer simulation to model track detections based on the tortuosity of actual lynx tracks. As part of our research, we backtracked 15 radio-collared lynx and mapped their tracks using a Trimble GEO Explorer III with data points taken at 2 s intervals. We randomly selected one 3-km track from each lynx and calculated the average track tortuosity by dividing total length by the linear distance traveled (Turchin 1998). This result was used when generating simulated tracks to ensure realistic track tortuosity.

Computer simulations required that we estimate daily travel distances of lynx. Daily movements as measured by radio telemetry are shorter than the animal's actual movement because of unrecorded tortuosity. In general, reported daily movements of lynx ranged from 1-9 km as measured using various methods, with most estimates from 1-4 km (Table 1). For modeling, we assumed that daily movements varied randomly from 1.0-4.0 km ($\bar{x}$= 2.5 km). We chose a conservative estimate of daily movements to better ensure that our model results addressed locating lynx at low densities where tracks were uncommon. A uniformly-distributed random number was drawn from this range for each trial. A simulated day's movement was completed when the linear distance traveled between the day's start and the current location exceeded the drawn random number. The program continued in this manner counting the number of days elapsed until the survey transect intersected a simulated track, and the number of elapsed days was written to an output file. Simulated tracks began at random locations within hypothetical, circular home ranges of 100 km^2 with

TABLE 1. Reported daily distances for lynx movement; only winter movements were included where both summer and winter movements were reported.

Study	Distance (km)	Method
Parker et al. 1983	8.8, male 7.6, female 6.5, juvenile	Cumulative distance based on 2 hour relocations
Ward and Krebs 1985	2.7 (95% CI = 1.8-3.7), hares common 2.4 (95% CI = 2.0-2.9), hares uncommon	Daily telemetry locations
Brittell et al. 1989	1.0, (range = 0.02–7.4), males 0.7, (range = 0.02-4.0), females	Daily telemetry locations
Apps 2000	3.8 (sd = 0.6), male 3.0 (sd = 0.4) female	Daily telemetry locations
Mowat et al. 2000	5-9 reported average of multiple studies	Snow tracking
Squires and Laurion 2000	2.8 (range = 2.5-3.3), 4 Montana males 3.2 (range = 2.5-3.9), 3 Montana females 2.7 (range = 0.7-9.5), Wyoming male 2.2 (range = 0.3-5.2), Wyoming female	Daily telemetry locations

an initial random direction. The length of simulated tracks was evaluated using travel distances that would be expected if we assumed that 1, 3, or 7 days had elapsed since the most recent snowfall.

The survey route was modeled as a straight, 8-km transect, randomly located within the 100 km^2 home range. The entire transect was incorporated into the home range, an assumption based on the study design in which the simulated survey track would be replicated within each cell of a contiguous grid. Hence, at least 8 linear km of survey track would be found in any arbitrary 100 km^2 circular area within the survey.

Snow-track Protocol

We used GIS to establish an 8 × 8 km grid across each survey area to define sample units. The size of this sample unit was slightly smaller than a typical female home range (Aubry et al. 2000) and was employed to reduce the chance of missing individuals, but was still efficient for searching large landscapes (Zielinski et al. 1995). Female lynx typically have smaller home ranges than males (Koehler 1990; Poole 1994; Slough and Mowat 1996). Establishing a grid of survey units covering the study areas ensured that our search effort was spatially well distributed across available habitats (Zielinski et al. 1995). After establishing the sample grids, we assigned a *high* or *low* priority to sampling units based on dominant habitat-type. Sample units in moist, Subalpine Fir forests were a *high* priority because these stands are more heavily used by lynx than drier forest types (McKelvey et al. 2000). Our protocol specified that "high" priority units be surveyed at least twice per winter (Halfpenny et al. 1995). Open-forest types, such as dry Lodgepole Pine, Quaking Aspen, and Ponderosa Pine (*Pinus ponderosa*), were "low" priority and were only searched once per winter. Open habitat types (large park lands, sage brush, tundra, agriculture) and high elevation sites (tundra, rock, and ice) are rarely used by lynx (Koehler 1990; Aubry et al. 2000; McKelvey et al. 2000) and were not surveyed.

Observers primarily searched for animal tracks by traveling 15-20 km/hr on roads and trails using snowmobiles. We saw no evidence that lynx were reluctant to cross snowed-in logging roads and trails (Squires; unpublished data; see also O'Donoghue et al. 1998). Survey units that could not be surveyed by snowmobile were searched on snowshoes to the extent possible. The protocol specified that we search 10 km in each 8 × 8 km sample unit choosing routes that preferentially traversed forested habitats with high horizontal cover. This search effort per sample unit was sufficient to traverse key areas within the unit, but still allowed us to efficiently search multiple sample units per day. High horizontal cover is an important component of Snowshoe Hare (*Lepus americanus*) habitat, the dominant prey species of lynx (Hodges 2000). Sample units that contained only dry, open forests were surveyed using routes that best bisected the search area. Our goal was a representative survey of sample units that were spatially well distributed across available habitats, while preferentially searching the *best* habitats in each unit to maximize the chance of detecting lynx.

We recorded the locations of all lynx tracks and the tracks of other carnivores using a Trimble GEO Explorer III GPS. Multiple crossings known to be the same animal and <100 m apart were recorded as a single detection. We measured (stride, straddle, length, width, depth; Halfpenny et al. 1995) and photographed all rare carnivore tracks to provide documentation. Track misidentification is a potential problem of snow-based surveys (Zielinski and Kucera 1995; Halfpenny et al. 1995), especially in areas where the species of interest is rare. We collected genetic samples (e.g., hairs, scats) from snow-tracks on the Wyoming study area to provide unequivocal documentation. To collect genetic samples, we followed presumed lynx tracks in search of scats or day beds. We carefully removed loose snow from daybeds until we reached the frozen bed layer. We then thoroughly searched the snow surface and used tweezers to secure hairs frozen in the snow. Hairs were stored in desiccant until the Rocky Mountain Research Station's Wildlife Genetics Laboratory, Missoula, Montana, extracted and analyzed DNA samples.

Snow-track surveys require trained personnel to be effective (Zielinski and Kucera 1995). We trained observers at our long-term lynx study area near Seeley Lake, Montana. Observers back-tracked radio-collared lynx to practice identifying tracks under diverse environmental conditions (e.g., forest type, snow conditions, topography). Following this training, we assumed that all observers could recognize lynx tracks.

Survey Verification

In the Garnet Range, we used radio-telemetry data to determine if the distribution of lynx within the study area was coincident with survey results. Lynx were trapped using specially designed box traps baited with carrion, beaver castor, and pie plates and wings for visual lures (Kolbe et al. 2003). Trapping was conducted throughout the winters of 2001-02 and 2002-03. Lynx were chemically immobilized using a syringe pole to administer a mixture of ketamine (10 mg/kg *Ketaset*®; concentration 100 mg/mL) and xylazine (1 mg/kg; concentration 100 mg/mL); this dose produced predictable immobilization periods (30-40 minutes) and stable vital signs. We fitted adult lynx with VHF radio transmitters (170 g), weighed, measured, and extracted blood from each for future DNA analysis. Kittens were fitted with a padded, 100 g collar that allowed for growth. We monitored lynx movements using aerial telemetry (90% of locations) approximately twice per month augmented with ground-based telemetry.

We combined all relocation points and calculated a 95% kernel home range to delineate the distribution of the local lynx population based on telemetry (Worton 1989; Seaman et al. 1999). We then overlaid a 95%

fixed kernel home range on the distribution of lynx, as delineated by snow tracking, to determine if the two methods yielded coincident distributions.

Results

Simulations of track detections

Computer simulations of track detections indicated different asymptotic relationships between the probability of detection and survey effort (number of visits per winter), based on the time between snowfalls sufficient to obliterate tracks (Figure 1). The probability of detecting lynx tracks during a single visit (8 km transect) to a survey unit ranged from approximately 0.23 for surveys conducted only one day after snowfall, to 0.78 for surveys conducted 7 days after a snowfall. If the survey effort was increased to three visits, then detection probabilities increased substantially from 0.58 for one day after snowfall to about 0.95 for surveys conducted 7 days after a snowfall. Even a modest survey effort of two visits would detect tracks approximately 80% of the time, provided more than 3 days had passed since the last snowfall.

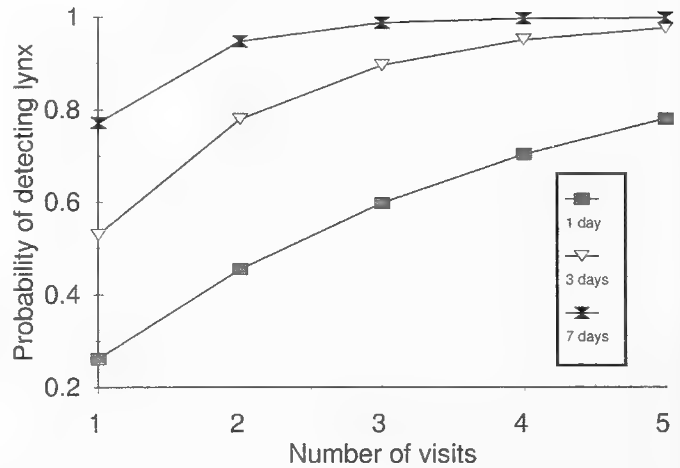

FIGURE 1. Computer-modeled relationship between the probability of detecting lynx and the number of visits to an 8 km survey transect pixel relative to the number of days since last snow.

Field test – Garnet Range, Montana

During winters 2001-2002 and 2002-2003, we surveyed for lynx on 242 km and 438 km of roads and trails, respectively. We documented 37 track detections of lynx in 4 of 12 survey units during winter 2001-2002, and 37 detections in 4 of 16 survey units during winter 2002-2003. In addition, we observed 115 lynx tracks during winter 2001-2002 and 53 in 2002-2003 in survey units, but not during the formal survey. These detections were made during trapping and related travel. We encountered a higher number of track-crossings during trapping because we only trapped in areas of high lynx use. The average elevation where we located lynx tracks was 1839 m (SD 97, range 1443 – 2012 m).

We trapped five lynx during winter 2001-2002, and two additional individuals during winter 2002-2003. We believed this sample of radio-collared individuals was a local census of lynx in the Garnet Range based on trapping results, recaptures, and field observations, but we could not formally test this perception.

Field test – Wyoming and Salt River Ranges, Wyoming

We conducted track-surveys for lynx in Wyoming during the winters of 1999-2000, 2000-2001, 2001-2002. During winter 1999-2000, we surveyed 1055 km in 32 sample units, and we detected one lynx track in the Salt River Range and a second track in the northeastern portion of the Wyoming Range. In addition, tracks from a family group were observed in the northeastern portion of the Wyoming Range by Wyoming Game and Fish Department biologists (B. Oakleaf, personal communication 2000). During winter 2000-2001, we surveyed 1103 km in 37 sample units, and 4 lynx tracks were detected in the northeastern portion of the Wyoming Range, and one set in the southwestern Salt River Range. We surveyed 1080 km in 34 sample units during winter 2001-2002 and detected no lynx.

Two tracks located during the 1999-2000 survey looked like lynx, but were poorly defined with each impression being a pedestal above the snow surface as a result of wind scouring. We followed two tracks for approximately 200 m until we located daybeds and collected five hairs. Two of the hairs contained sufficient DNA to amplify and the species identification was verified as lynx.

Survey Verification

The distribution of lynx in the Garnet Range, as defined by a 95% fixed kernel home range of all marked animals (n= 96 locations from 7 individuals, = 14 locations per individual, Figure 2B) combined, subsumed 97% of all tracks detected during snow-track surveys. The general distribution of lynx in the Garnet Range as defined by radio telemetry and snow-track surveys was coincident (Figure 2A).

We documented too few lynx detections in the Wyoming and Salt River ranges to delineate a distribution based on snow-track surveys. However, biologists with the Wyoming Game and Fish Department trapped two lynx in the northeastern portion of the Wyoming Range during the winter of 1996-1997 (B. Oakleaf personal communication 2000). The winter home ranges of these two individuals were restricted to the northeastern portion of the Wyoming Range in the same approximate area as 5 of the 7 track detections from our survey.

Discussion

Snow-tracking has been used to document the presence/absence of carnivores (Zielinski and Kucera 1995), and continues to be an important technique, especially when the organisms of interest are rare and difficult to observe. One primary appeal of using track-based surveys for presence/absence sampling is the method's

A.

B.

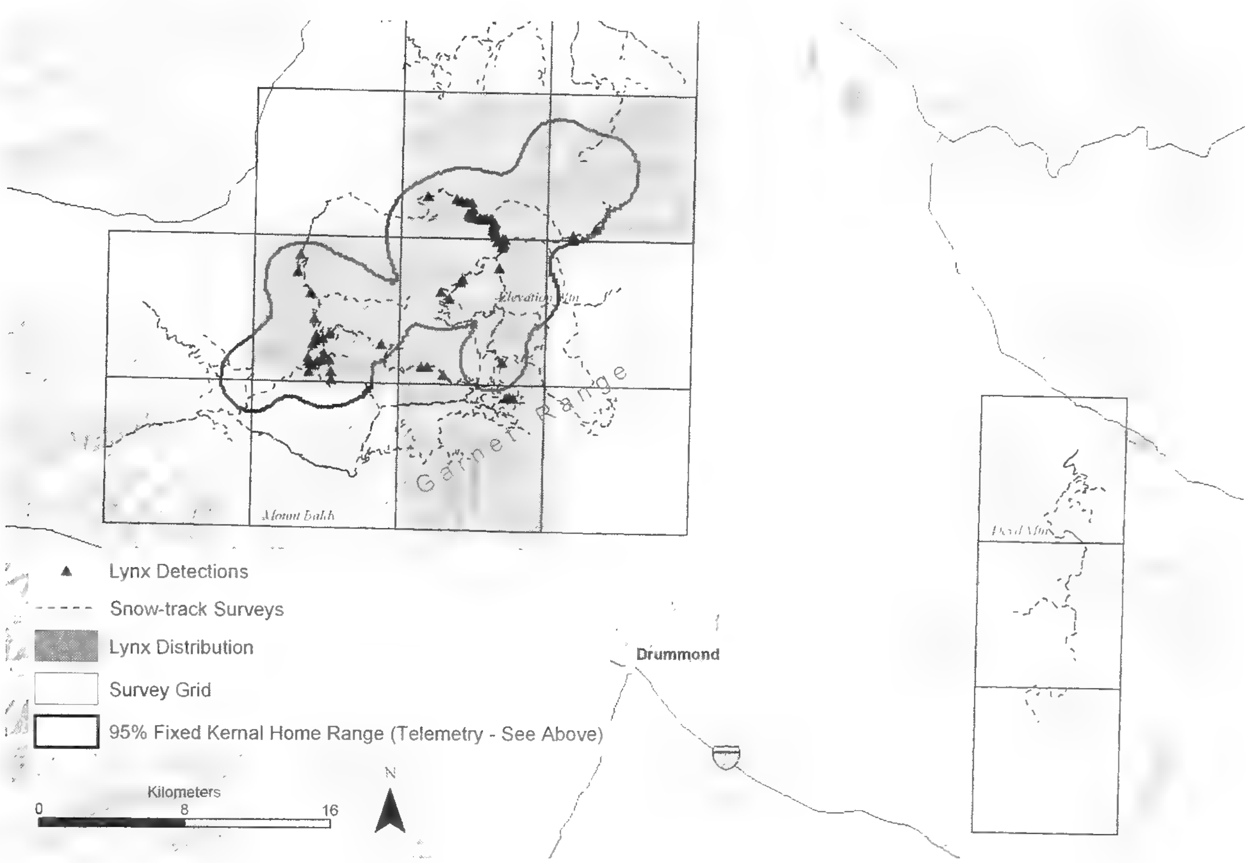

FIGURE 2. The local distribution of lynx in the Garnet Range delineated from: (A) radio telemetry of all individuals combined (95% fixed kernal, $n = 96$ locations from 7 individuals, $\chi = 13$ locations per individual) compared to, (B) the local distribution based on sample units with track detections.

sensitivity to changes in use patterns, especially for species like lynx that are highly mobile and have large home ranges (Ward and Krebs 1985; Poole 1994; Slough and Mowat 1996; Aubry et al. 2000). Changes in lynx occupancy can be quickly detected across extensive areas using snow-track surveys. For example, general occurrence data from 1842-1998 suggested that lynx had a long-term history of occupancy in the Salt River and Wyoming Ranges (see McKelvey et al. 2000: Figure 8.17), and the perception that lynx were currently distributed throughout the Wyoming and Salt River Ranges was shared by local managers. Snow-track surveys conducted in a representative manner throughout the Wyoming and Salt River Mountain ranges provided evidence that lynx were present in 1999, and this result was confirmed using genetic analyses in 2000. However, the low overall detection rate coupled with the lack of tracks in 2001 indicated that lynx were rare and only located in a small area in the northern part of the Wyoming range.

In areas with many track detections, snow-track surveys can yield more than simple presence/absence data. Results from the Garnet Range demonstrated that snow-track surveys conducted in a representative manner can also be used to delineate the local distribution of lynx. The high overlap in distributions determined through telemetry and survey data suggested that snow-track surveys can at least coarsely define the local distribution of lynx (Figure 2). We acknowledge that survey data are more limited than telemetry data given that only winter movements are documented and the resulting distribution is coarse-scale relative to the sample unit. However, even a coarse-scale understanding of local distributions is useful to habitat managers. Thus, based on our data in the Garnet Range, we believe that snow-track surveys that are spatially well distributed across all available habitats can be used to estimate the local distribution of lynx during the winter.

If lynx are abundant in an area, a 5% misidentification rate would have little impact on management decisions. However, in areas where lynx are very rare, a track misidentification can have serious management ramifications. One way to address the chronic problem of track misidentification is to view the track as a "*collection device*" for obtaining genetic samples rather than a primary method of species identification. Genetic verification provides definitive species documentation, regardless of the observer's ability to identify rare carnivores based on track characteristics. We therefore recommend that genetic identification be included whenever proper identification of an individual set of tracks is critical.

Snow-track surveys are labor intensive, and we have only used this method at a mid or "meso" spatial scale, where we searched all sample units. Such an intensive approach would be impractical across large landscapes, for example a large portion of a state. Although we have not conducted a snow-track based survey at a "state" scale, adaptive cluster sampling may provide a promising method of achieving a representative sample across very large landscapes (Thompson 1992). Adaptive cluster sampling is effective for delineating clumped distributions, which we believe is the case for lynx at the southern extent of the species' range (Aubry et al. 2000).

Snow-track surveys are often conducted when track characteristics are most distinctive, usually within a day or two following fresh snowfall. This constraint limits the utility of snow tracking because the probability of detecting lynx and other rare carnivores is a function of the time since last snow. The more time that lynx have to travel and establish long tracks, the more likely it is that their tracks will be detected on a survey route. For example, our simulations suggest almost a 100% probability of detecting lynx in two entries 7 days after a snowfall compared to a 43% probability of detection if the area was searched 1 day from snowfall (Figure 1). In the areas we surveyed, snow accumulations over 5 cm were recorded on 22 and 24 (17-18%) of the days for the Garnet and Wyoming ranges, respectively, and the snow-free periods between storms varied from 4-6 days (U.S.D.A., Natural Resources Conservation Service, SNOTEL data). The ability to correctly identify "old" tracks by incorporating genetic samples allows biologists to survey for rare carnivores when the probability of detection is high, even under poor tracking conditions.

The winter surveys that we used to detect lynx in Wyoming and Montana had the following key elements: (1) sample units were representative in terms of spatial coverage, but still focused on high-quality habitats that maximize lynx detections; (2) search effort per survey grid was defined and consistent across the survey area; (3) search intensity was consistent with simulated results indicating a high probability of detection, (4) technicians were well trained in track identification and data recording; (5) track identifications were rigorously documented and spatially referenced; and (6) lynx tracks were searched for genetic samples to confirm identification. We believe that surveys having these characteristics can be used to rigorously define the range of local lynx populations, and could be extended to the regional scale using adaptive cluster sampling.

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Hummock Vegetation at the Arctic Tree-line near Churchill, Manitoba

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Hummocks, small earth or peat mounds, are widely distributed in the arctic and develop as a consequence of biomass accumulation and cryoturbation in the active layer. There is general agreement that the type of vegetation covering peat hummocks may alter the accumulation rate of organic material and thus hummock growth and local carbon sink dynamics. Studies on hummock plant community compositions from the arctic are very scarce. Here, I present results of a case study from the arctic tree-line near Churchill, Manitoba (Canada). Vegetation composition, hummock height and soil moisture content were recorded in 40 peat hummocks located along a tree-line gradient from open forest to tundra. Based on a cluster analysis I found three moss-dominated types of hummock vegetation, according to (1) a *Tomenthypnum nitens* (golden fuzzy fen moss) type on low hummocks, (2) a *Hylocomium splendens* (stair-step moss) type on medium-sized hummocks, and (3) a *Pleurozium schreberi* (red-stemmed feathermoss) type on hummocks higher than 60-70 cm. I found hummock height to increase towards the forest interior with decreasing water content of the upper organic layer on the hummock top. This is indicated by a significant change in vegetation composition towards drought resistant moss species on higher hummocks. Furthermore, species richness decreased with increase in hummock height. Based on evidence from historical tree-line invasion the overall results suggest that hummock height increases due to peat accumulation over the course of time resulting in a typical change in plant community composition.

Key Words: peat hummocks, *Tomenthypnum nitens*, Golden Fuzzy Fen Moss, *Hylocomium splendens*, Stair-step Moss, *Pleurozium schreberi*, Red-stemmed Feathermoss, subarctic, forest-tundra ecotone, Hudson Bay Lowlands, Manitoba.

Hummocks are small, up to 1 m high soil mounds widely distributed in the northern boreal, sub-arctic and arctic permafrost regions (e.g., Lundquist 1969; Mackay 1980). Generally, two types of hummocks can be classified: earth hummocks and peat hummocks. Earth hummocks may develop as a result of frost heave and cryoturbation processes where the organic layer overlies fine-grained frost-susceptible soils (Quinton et al. 2000). In contrast, peat hummocks grow as the result of the accumulation of organic material and where the surface of the uppermost mineral layer inside the hummock is positioned below the surrounding ground level (see Dredge 1992). Both hummock types may be perennially frozen or, as a result of warmer summer climate and lower latitude, completely thawed (Zoltai and Pettapiece 1974; Tarnocai and Zoltai 1978). As a transitional form they may be partially frozen with ice lenses remaining in the hummock core during the summer period.

Even though hummocks are a common landscape feature and hummocky terrain covers a large proportion of Arctic Canada (Tarnocai and Zoltai 1978), scientific studies focusing on the vegetation structure of peat hummocks are very scarce. This lack of empirical data and also the potential role of peat hummocks for the carbon dynamics in the northern hemisphere emphasize the need to investigate the spatial distribution of major hummock plant community types. Besides the prevailing local climate, carbon storage in the arctic is strongly influenced by vegetation composition and succession (see Camill et al. 2001). Thus, in order to appreciate carbon dynamics in the northern hemisphere acknowledge of potential carbon sinks (such as peat hummocks) and their major plant community types are necessary. This enables evaluation of ecological factors which may alter accumulation or decomposition rates of organic material and related carbon dynamics. For example, mosses which often dominate hummock vegetation have the potential to play a key role in modifying decomposition rates and the thermal and hydrological regime of arctic soils (Beringer et al. 2001). Here, I present results of a case study on vegetation composition, succession and physiognomy of 40 peat hummocks located along an arctic tree-line transect from tundra to open forest in the Hudson Bay Lowlands near Churchill, Manitoba (Canada).

Methods

Study area

The study site is situated at the open forest tree-line near Twin Lakes, a flat-topped glacial kame deposit approximately 25 km southeast of the town of Churchill (Figure 1). The open forest vegetation is composed of a mix of Tamarack (*Larix laricina* [Du Roi] K. Kock) and White Spruce (*Picea glauca* [Moench] Voss) with interspersed Black Spruce (*Picea mariana* [Mill.] Britt Sterns & Pogg). The present tree line north of Twin Lakes is extended into a wet sedge fen

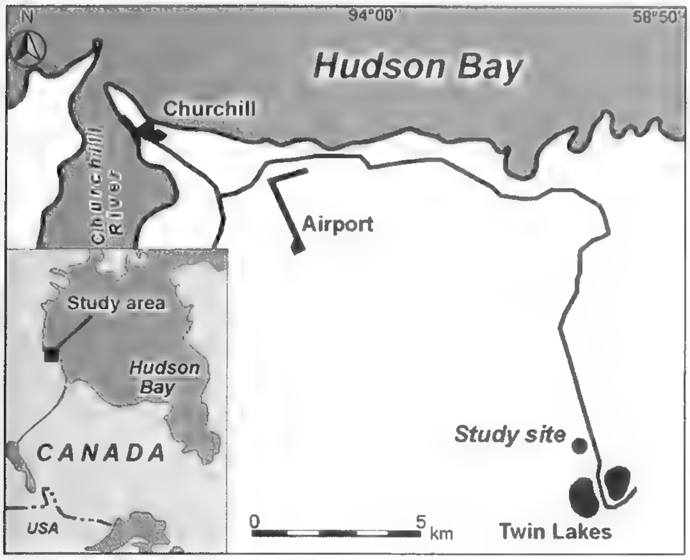

FIGURE 1: Location of the study site in the Hudson Bay Lowlands near Churchill in northeastern Manitoba (Canada).

predominated by *Carex aquatilis* (Water Sedge) and *Carex limosa* (Mud Sedge). The current position of the tree-line has moved up to 150 m towards the open sedge fen within the last 70 years (see Scott et al. 1987). Here, the current tree-line is composed of *L. laricina* which established during the latest forest invasion. Whereas young *L. laricina* tree-line stands are characterized by small hummocks, the open forest interior towards Twin Lakes is dominated by mature *P. glauca* trees on typically hummocky terrain with large hummocks and inter-hummock, water-filled troughs. The nomenclature for plants follows after Porsild and Cody (1980).

Sample design

During July 1999 I established a 250 m transect from the open sedge fen towards the forest interior. I sampled each hummock (total 40) that occurred within a 5 m wide corridor along the transect line. For each hummock I measured its height from the top to the base. Vegetation composition was studied by using a frame placed on top of each hummock. The frame size 0.5 * 0.5 m was small enough to cover the tops of the smallest hummocks. For larger hummocks I chose homogeneous parts of the vegetation on the hummock top. Vascular plant cover within the sampling frame was then estimated for each plant species separately using the decimal Londo-scale (Londo 1984). Within each frame soil samples were taken from the upper organic layer (5 cm – 20 cm depth) during one sampling day and then water content gravimetrically determined (samples were 24h oven-dried at 95°).

Statistical analysis

To group species datasets Mulva's minimal variance clustering technique using van der Maarel's coefficient was used (Wildi and Orlóci 1996). Simple linear regression was used to examine the relationship between hummock height as an independent variable and water content, species richness, and similarity of species composition (species turnover rate) as the dependent variables. For the species turnover rate between sample i and j hummocks were ranked by height and β defined according to:

$$\beta = \frac{l + g}{i + j} \qquad \text{eqn 1,}$$

where l is the number of species that disappeared between sample i and j and g the number of new species.

Results

Hummocks are a dominant micro-topographical feature at the open forest tree-line. For the transect area I found a mean density of 320 hummocks ha^{-1}. However, density was significantly higher in mature *P. glauca* stands towards the open forest. The majority of hummocks were predominately covered by either one of the moss species *Tomenthypnum nitens* (Golden Fuzzy Fen Moss), *Hylocomium splendens* (Stair-step Moss) or *Pleurozium schreber* (Red-stemmed Feathermoss) whereas herbaceous plants where less frequent. This was confirmed by a resemblance matrix of a cluster analysis for 40 sample plots (Figure 2). The *Tomenthypnum nitens*-group was mainly composed of *Polygonum viviparum* (Alpine Bistort), *Equisetum variegatum* (Variegated Scouring-rush), *Andromeda polifolia* (Dwarf Bog-rosemary), and *Carex aquatilis* (Water Sedge), indicating somewhat wet conditions (see Table 1). In contrast, hummocks with *Hylocomium splendens* had a more or less Dwarf Shrub dominated cover with species such as *Vaccinium vitis-idaea* (Lingonberry), *Ledum groenlandicum* (Common Labrador Tea), and the lichen *Cladina rangiferina* (Grey Reindeer Lichen). The third major group was dominated by *Pleurozium schreberi* associated with *Betula glandulosa* (Dwarf Birch) and the grass *Calamagrostis canadensis* (Blue Joint), indicating somewhat dry conditions.

The species groups that were revealed by the cluster analysis showed significant affiliation in terms of transect position and respective hummock height. The *Tomenthypnum nitens*-group was mainly found on low hummocks (see Table 1) located near the tree-line (Figure 3a). Here, the organic layer on hummock tops was mostly saturated (Figure 3b), typical for the hydrological situation near the sedge fen. Hummocks with *Hylocomium splendens* had medium-sized heights and an intermediate transect position, whereas *Pleurozium schreberi*-hummocks with heights above 60 cm where predominately found in the open forest interior.

Overall, there was an increase in hummock height towards the open forest (Figure 3a, $R^2 = 0.57$). Increase in height had a significant negative effect on organic layer water content (Figure 3b, $R^2 = 0.46$). In terms of patterns of plant species richness, species number decreased with increase in hummock height (Figure 3c, $R^2 = 0.42$; see also Table 1). Total number of plant species found, including mosses and lichens, was 45, and 8.1 species per sample plot on average. Moreover, intermediate hummock heights were indicated

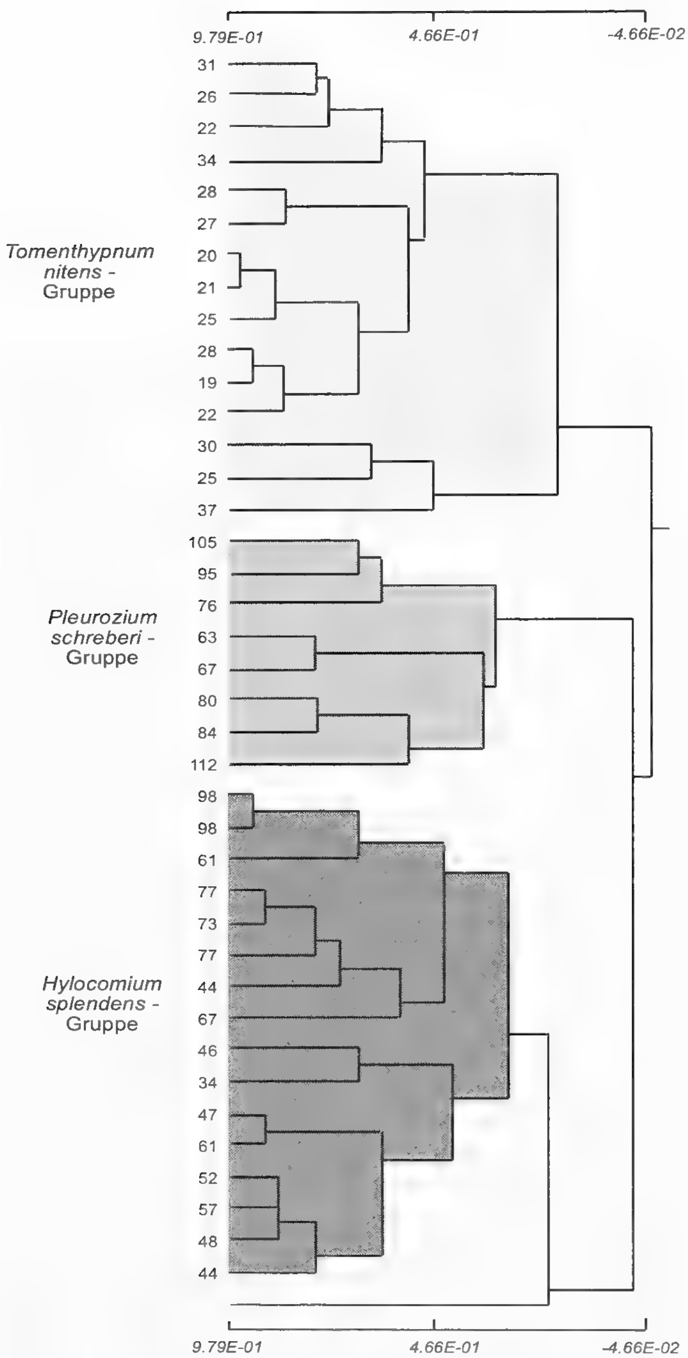

FIGURE 2: Cluster analysis of 40 hummock vegetation samples. Three moss-dominated plant community types are distinctive according to the occurrence of *Tomenthypnum nitens*, *Hylocomium splendens* and *Pleurozium schreberi*. Numbers for each sample indicate respective hummock height given in cm.

by a relatively high species turnover rate when plots were ranked by height (Figure 3d), i.e., species composition showed a higher variation than vegetation of either low or high hummocks.

Discussion

The results of this field study from the arctic tree-line near Churchill indicate a significant relationship between hummock height and the position along the tree-line gradient on one hand, and hummock height and water content, vegetation type, species richness, and species turnover on the other hand. Increasing hummock height towards the forest interior seemed to reduce moisture availability for mosses on the hummock tops and facilitate the establishment of species-poorer communities with drought-resistant vascular plants. Interestingly, *Tomenthypnum nitens, Hylocomium splendens* and *Pleurozium schreberi* are ubiquitous moss species with a wide ecological distribution (Nicholson and Gignac 1995). However in this study they showed distinct distribution patterns in relation to hummock height and soil water availability within a relatively small area.

The plant community composition of peat hummocks described here are the first inventory of hummock vegetation in the Hudson Bay Lowlands, the largest contiguous wetland in North America (Boudreau and Rouse 1995). Other published studies are concerned with the Mackenzie delta region where earth hummock physiology and plant species composition is completely different. Thus, they are difficult to compare (see e.g., Zoltai and Pettapiece 1974). It is unclear whether peat hummocks accumulate organic material and increase in size regardless of the local environment or whether this is driven by the micro-topography such as the establishment of trees. However, the local tree-line extension near Twin Lakes suggests that once young trees establish on formerly open tundra, peat hummocks may develop where shading and increased moisture from trapped snow coincide with feather moss establishment (Scott and Hansell 2002). Moreover, the occurrence of rotten tree stumps in the subsoil of the former centre of large, degraded hummocks (J. Tews personal observation) may support the latter hypothesis and is additional evidence that these hummock are formed by organic matter accumulation, not by cryogenic processes as is the case with earth hummocks.

Based on this study I hypothesize that hummock plant community composition at the tree-line near Twin Lakes is changing in the course of hummock growth. This is important as accumulation rates of peat (and thus carbon dynamics) are strongly influenced by local vegetation succession (Camill et al. 2001). Bello and D'Souza (2000) found that with increase in hummock height, accumulation rates of organic material decrease. For an average height of 20 cm they estimated an accumulation rate of 20 g m^{-2} $year^{-1}$, for 60 cm hummock height only 5 g m^{-2} $year^{-1}$. These results largely confirm growth rates found for *Tomenthypnum nitens* and *Hylocomium splendens* (see Busby et al. 1978). In general, decomposition rates increase with decreasing water saturation during the short summer period. However, due to this rather small array of data, current available data may not support proper estimates of community-specific accumulation rates necessarty to model large-scale spatial and temporal carbon dynamics in the arctic. Thus, based on the knowledge of the predominant types of hummock plant communities, more studies on community-specific accumulation rates are needed.

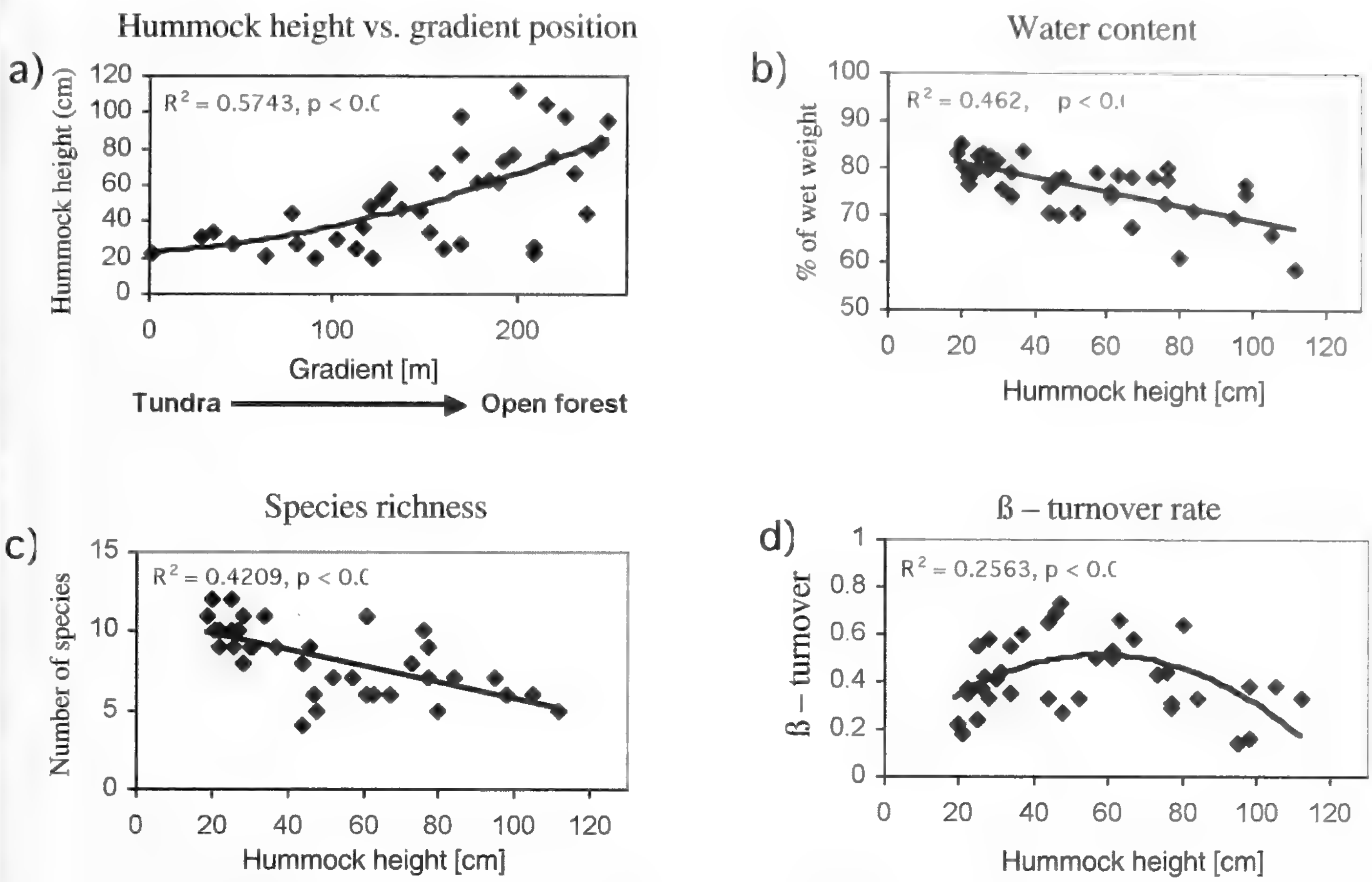

FIGURE 3: Simple regression analysis for: (3a) hummock height vs. gradient position along the tree-line from open tundra to forest; (3b) water content of upper humus layer on hummock top vs. hummock height; (3c) total number of plant species vs. hummock height; (3d) species turnover rate vs. hummock height.

Another current environmental issue makes the matter even more complex: global climate change. On average, climate change in the arctic may yield more precipitation and warmer summers (see Sonesson 2002). Based on these assumptions, there is general agreement that global climate change will alter decomposition rates and carbon storage (e.g., Gorham 1997; Earle et al. 2003). Dormann and Woodin (2002) pointed out that the driver of future change in arctic vegetation is likely to be increased nutrient availability, aris-

Table 1: Typical species composition of hummocks at the arctic tree-line near Churchill, Manitoba. The table shows 27 characteristic hummock samples out of a total of 40 samples (13 samples with less significant community affiliation are not shown). Three moss-dominated plant community types are evident according to *Tomenthypnum nitens*, *Hylocomium splendens* and *Pleurozium schreberi*.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Hummock height	21	19	26	28	34	31	25	20	25	37	22	22	27	98	47	98	73	77	61	105	95	76	112	77	84	67	80
# of species	10	11	9	11	11	9	12	12	10	9	10	9	10	6	6	6	8	7	6	7	7	10	5	9	7	6	5
Tomenthypnum nitens	9	10	10	10	9	8	10	9	8	1	10	9	9														
Polygonum viviparum	.1	.2	.4	.2	.4	.4	.4	.2	.4	.2																	
Equisetum variegatum	.4	.4	.2	.4	.4		.2	.4	.1		.4	.2	.4														
Scirpus caespitosus	.2				3			.4			.4																
Carex aquatilis	1	.4	.2	.4			1	1				.4	1														
Andromeda polifolia	2	.1		.2			1	1			.2	1	.4														
Platanthera obtusata				.1						.1																	
Oxyccocus microcarpus			1	.4				.1					.4														
Rubus acaulis	.2				1	.4	.4		.1	.1			.4														
Pedicularis lapponica		.2						.2																			
Salix reticulata		.2			1						.2		2														
Aulacomnium palustre	1						.4	1	2	9		.4	1														
Hylocomium splendens														9	6	10	8	8	6	2	1	6	1	8	1		
Vaccinium vitis-idaea														3		2	3	2	.2	.4	2	.4	7	2	1	.4	
Ledum groenlandicum														8		6				5	4	4		.2			
Ledum decumbens														1		2					2	1			3		1
Cladina rangiferina															4		.1	.4	2		.4	1	2	1	6	2	2
Pleurozium schreberi																				8	7	4	5	1	3	9	6
Betula glandulosa																				2							
Calamagrostis canadensis																					.2				.1		

ing for example from temperature-induced increases in mineralization. In particular, the response of plant growth to rising CO_2 levels appears to depend on nutrient availability (Heijmans et al. 2002). In the arctic vegetation nitrogen is tightly controlled by the moss layer (e.g., Li and Vitt 1997; Sommerkorn et al. 1999). Moreover, mosses such as *Pleurozium schreberi* have been reported to be able to fix nitrogen in symbiosis with a cyanobacterium (i.e. *Nostoc* sp.) (Deluca et al. 2002). Thus, increase in average summer temperatures due to climate change and the resulting increase in mineralization rates may potentially decrease local carbon storage with severe consequences for the global carbon cycle. However, scientific research is far from establishing realistic future scenarios. For example, in the context of our study, it was recently shown that individual bryophyte species displayed contrasting responses to changes in the nutrient supply and that they should not be grouped as a single functional type (Gordon et al. 2001). From this it is evident that further detailed hummock vegetation studies are needed, particularly in the arctic where the impact of climate change is likely to be most effective.

Acknowledgments

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Effects of Lodgepole Pine Dwarf Mistletoe, *Arceuthobium americanum*, on Jack Pine, *Pinus banksiana*, Growth in Manitoba

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Epp, Brock, and Jacques C. Tardif. 2004. Effects of Lodgepole Pine Dwarf Mistletoe, *Arceuthobium americanum*, on Jack Pine, *Pinus banksiana*, growth in Manitoba. Canadian Field-Naturalist 118(4): 595-601.

The Lodgepole Pine Dwarf Mistletoe (*Arceuthobium americanum* Nutt. ex Engelm.) is an important pathogen of Jack Pine (*Pinus banksiana* Lamb.). Dwarf Mistletoe alters tree form, suppresses growth, and reduces volume and overall wood quality of its host. Stem analysis and a 3-parameter logistic regression model were used to compare the growth of heavily and lightly to non infected Jack Pine trees. At the time of sampling, no significant reduction in diameter at breast height and basal area were observed in heavily infected trees. However, a significant reduction in height and volume and an increase in taper were observed in heavily infected trees. Growth models predicted a 21.1% lower basal area, 23.4% lower height and 42.1% lower volume by age 60 for the high infection group.

Key Words: Lodgepole Pine Dwarf Mistletoe, *Arceuthobium americanum*, Jack Pine, *Pinus banksiana*, stem analysis, logistic regression, basal area, height, volume, tree growth, productivity, Manitoba.

Le Faux–gui du pin (*Arceuthobium americanum* Nutt. ex Engelm.) est un important agent pathogène du Pin gris (*Pinus banksiana* Lamb.). Le faux–gui modifie le défilement des arbres hôtes, réduit leur croissance et leur volume marchand ainsi que la qualité du bois. L'analyse de tige et la régression logistique à trois-paramètres ont été utilisés afin de comparer l'accroissement entre les Pins Gris sévèrement atteints et faiblement atteints. Au moment de l'échantillonnage, aucune réduction significative du diamètre à hauteur de poitrine ou de la surface terrière ne fut observée chez le groupe sévèrement atteint. Toutefois, les arbres atteints ont enregistré une baisse significative de la hauteur et du volume ainsi que du coefficient de défilement. Les modèles de régression ont prédit une perte de 21,1% en surface terrière, de 23,4% en hauteur et de 42,1% en volume pour les pins gris fortement atteints par le faux–gui à un âge de 60 ans.

Mots clés: Le Faux–gui du pin, *Arceuthobium americanum*, Pin gris, *Pinus banksiana* Lamb., analyse de tige, régression logistique, surface terrière, hauteur, volume, croisssance, productivité, Manitoba.

Jack Pine (*Pinus banksiana* Lamb.) is an important commercial tree species because of its pole-like growth form, and as a pioneer species, it is relatively easy to regenerate following harvest (Rudolph and Laidly 1990; Sims et al. 1990). An important pathogen of Jack Pine is Lodgepole Pine Dwarf Mistletoe (*Arceuthobium americanum* Nutt. ex Engelm.). There are five species of Dwarf Mistletoe known in Canada, of which *A. americanum* is the most widely distributed, extending from British Columbia to southeastern Manitoba (Hawksworth and Wiens 1996). Individual species of Dwarf Mistletoe are generally host-specific, able to infect only a few tree species. In the case of *A. americanum*, other susceptible hosts include Lodgepole Pine (*Pinus contorta* Dougl. ex Loud.) and Ponderosa Pine (*Pinus ponderosa* Dougl. ex P. & C. Laws.).

As of 1996, there were 670 000 ha of forest with severe *A. americanum* infections in Alberta, Saskatchewan and Manitoba (Brandt et al. 1998). In Manitoba, approximately 8.7% of mature Jack Pine stands in important growing regions were infected by Dwarf Mistletoe (Baker et al. 1992). This has resulted in a loss of up to 7.9% of the total pine volume in these regions (525 224 m^3 out of 6 648 405 m^3) and a loss of up to 70.3% within the infected stands. Aside from the substantial volume losses, there is also a reduction in wood quality, making wood less merchantable. Wood of Lodgepole Pine infected by *A. americanum* exhibited greater longitudinal shrinkage and was weaker in strength when compared to uninfected trees because of the production of tree-rings having a lower percentage of latewood, shorter tracheid length, and higher resin content (Piirto et al. 1974). Generally, Dwarf Mistletoe deprives its host of water and nutrients, thus reducing height and diameter growth as well as seed production, and weakening the tree (Franc and Baker 2000). Dwarf Mistletoe alters tree form by disrupting apical dominance (Tinnin and Knutson 1980) through formation of witches' brooms. Because Dwarf Mistletoe derives all of its nutrients from host tissue and fixes little or no carbon dioxide for its own use, witches' brooms act as sinks for metabolites produced in other parts of the host (Hull and Leonard 1964a, 1964b). Douglas-fir and Western Larch infected by *A. douglasii* and *A. laricis*, respectively, exhibited a significant increase in leaf to sapwood ratios in heavily infected trees, altering resource

allocation processes and reducing the overall water-use efficiencies (Sala et al. 2001).

The long incubation period characterized by the life cycle of *A. americanum* (Hawksworth and Wiens 1996) poses a problem in the early detection of initial infections. In forest management situations, the current most effective methods of treatment are removal of heavily infected trees and isolation of infected stands by planting buffer zones of incompatible host species (Franc and Baker 2000). Even-aged silvicultural systems are often effective in controlling Dwarf Mistletoe, as the entire overstory may be removed.

No one has quantified volume losses on individual Jack Pine trees due to infection by Dwarf Mistletoe. One study examined the effect of *A. americanum* on the growth of Lodgepole Pine (Baranyay and Safranyik 1970). Within Manitoba, Baker et al. (1992) studied the impact of Dwarf Mistletoe on Jack Pine trees at the stand scale, focusing on loss of wood volume in the forest stands. The objective of this study was to compare the growth of heavily infected Jack Pine trees to that of non-infected or lightly infected Jack Pine trees based on differences in diameter at breast height (dbh), basal area, height, volume, and stem form. We hypothesized that there was a significant reduction in total cumulative dbh, basal area, height, and volume growth rate in trees infected with Dwarf Mistletoe.

Methods

The sampling area is located about 97 km northeast of Winnipeg, Manitoba (Figure 1) within Belair Provincial Forest (50°38'N, 96°29'W, 250 meters above sea level). The underlying bedrock consists of Archean granites and gneisses (Manitoba Geological Survey 2002*). The closest meteorological station is located at Pine Falls about 21 km from the sampling area. The climate is continental (Burton et al. 1998). The mean annual temperature for Pine Falls is 2.1°C, and the total annual precipitation is 538.5 mm (Environment Canada 2002*). In winters, the average minimum temperature reaches –23.5°C in January, and in summers, the average maximum temperature reaches 25.3°C in July.

The sampling site consists of a small, open, fire-originated Jack Pine stand, and is bound by Provincial Highway 11 to the south and a recent cutover to the north. The sample site is located near the south-eastern limit of the lodgepole pine dwarf mistletoe geographical distribution in Manitoba (Baker et al. 1992). Physically, the site is characterized by level, homogeneous terrain. The site is also homogeneous with regards to stand origin, slope variation and understory vegetation. Due to the small size of the infected stand, and the localized nature of the mistletoe infections, the number of trees for sampling was limited. There are epicentres of Dwarf Mistletoe infections scattered throughout the area. Within the sampling site, there is a relatively even scattering of heavily infected trees intermixed with lightly and non-infected trees (Figure 1).

Three transects were established approximately 50 m apart, oriented in a north-south direction, extending north from Provincial Hwy. 11. Ten sampling points were randomly established along the three transects, and the surrounding area was divided into four quadrants. One of the four quadrants was randomly selected in which the two nearest trees to the point were selected; one heavily infected tree and the nearest lightly or non-infected tree between 40 and 60 years of age. Trees with noticeable fire scars, fungal infections, or injuries were avoided to minimize the effects of other disturbances on tree growth. Trees that exhibited excessive branching or forking on the main stem were also avoided to simplify stem analysis. Trees were selected up to 50 m from plot centre, as long as they remained within the stand boundaries. If no trees matching our criteria were found within the selected quadrant, sampling was done in the next quadrant in numerical order. This method helped to eliminate bias by selecting the closest trees to the sampling points. Once candidate trees were selected, they were numbered, marked with a north-orientation line, marked at 0.5 m and 1.3 m, and locations were recorded with a GPS unit (Figure 1). Sampling took place in late July – early August 2002.

Prior to felling, the infestation index of the trees was estimated using the Hawksworth 6-class system (Hawksworth 1977). Infection was most easily determined from the ground by the presence of witches' brooms. Trees with an infestation index of 0 to 3 were classified as lightly infected, whereas trees with an index of 4 to 6 were classified as moderately to heavily infected. In order to take into account the competition of other trees, the dbh and distance of the nearest tree in each cardinal direction were measured.

Following felling of the trees, tree height was recorded and stems were sectioned at 0 m, 0.5 m, 1.3 m, and then 1-m intervals until stem diameter was less than 1 cm. Sections at points of the stem where branches emerged were avoided, and the adjusted height was recorded. For each cross-section, diameter inside-bark and outside-bark were measured along two diameters perpendicular to each other. At the laboratory, age of each cross-section was measured, and the pointer-year method of cross-dating was used to validate ages (Yamaguchi 1991). Following dating, stem analysis was performed on each tree to determine annual increments. Ring width measurements were done using the WinDENDRO™ v. 2002a program (Régent Instruments Inc. 2002*), and annual increments were calculated using XLSTEM™ 1.3a (Régent Instruments Inc. 1999*). Each cross-section was scanned with a high-resolution scanner and saved as a digital image. An image resolution of 800 dpi was used, except for cross-sections exhibiting high levels of suppression, where a resolution of 1600 dpi was used. For one tree, suppression was too great for ring detection by the WinDENDRO™

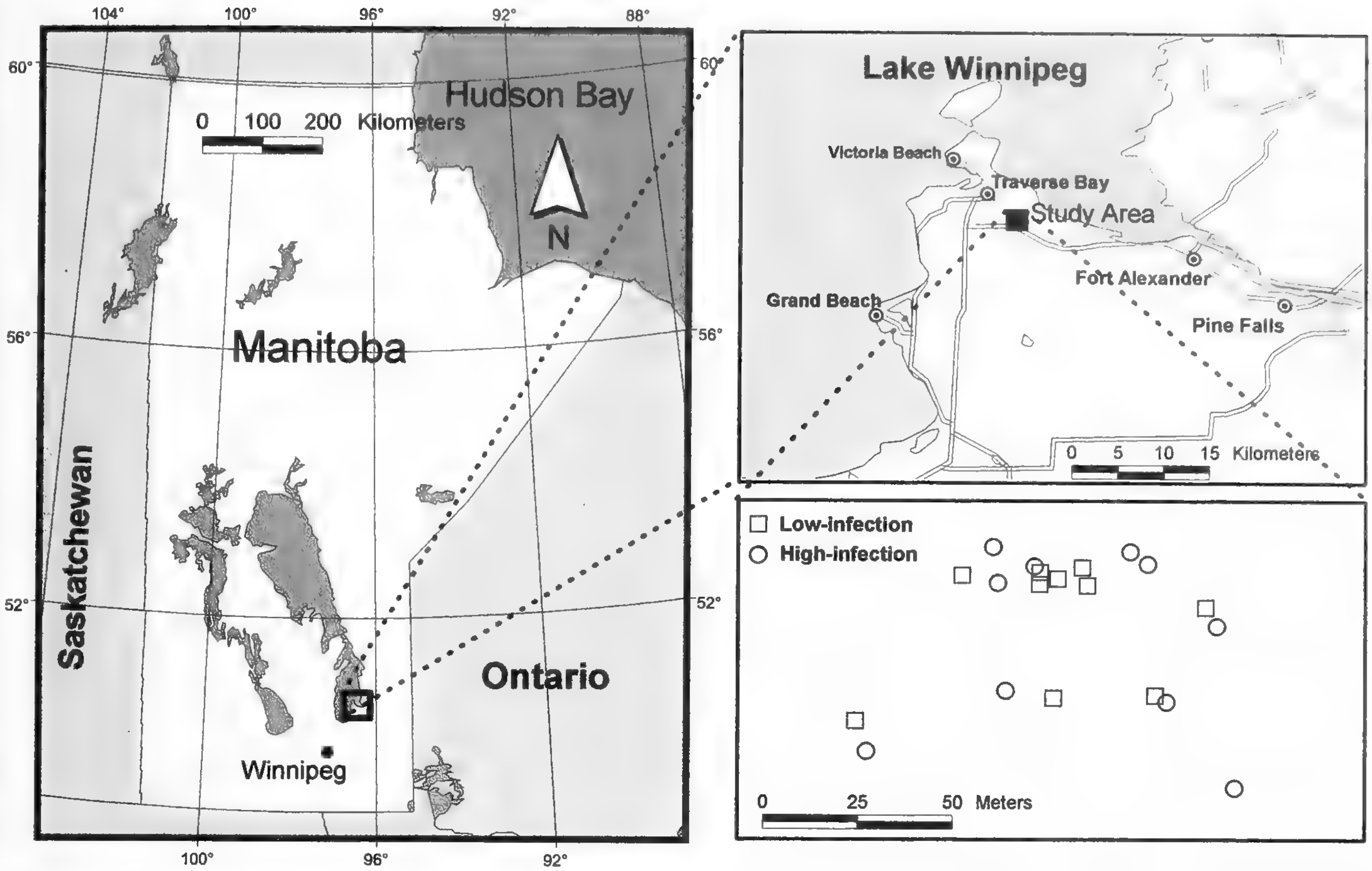

FIGURE 1: Location of the study area and distribution of the sampled trees. The lower right panel illustrates the relative position of the sampled trees and their infection level in the jack pine stand. Empty circles correspond to heavily infected trees, and empty squares correspond to lightly or non-infected trees.

program, so measurements were performed manually at a magnification of 50× using a Velmex measuring stage to a precision of 0.001 mm. Ring widths were measured, starting at the pith, along four radial paths in the north, east, south and west directions.

Data obtained were examined for differences between the two infection groups with regards to age, competition index, dbh, basal area, height, volume and stem form. The competition index was modified from Hegyi's distance weighted size ratio index (Avery and Burkhart 2002):

$$CI_i = \sum_{j=1}^{4} \frac{D_j / D_i}{DIST_{ij}}$$

where CI_i is the competition index for the subject tree, D_j is the dbh of the jth of four competitor trees (N, E, S, and W directions), D_i is the dbh of the subject tree, and $DIST_{ij}$ is the distance between the subject tree and the jth competitor tree. Basal area at dbh was calculated for each tree by using the formula for the area of a circle. Tree volume without bark was calculated by applying Smalian's formula for volume (Avery and Burkhart 2002) to each segment. The volume of each segment was then added to obtain tree volume. Stem form expressions were determined using the Girard form class (Avery and Burkhart 2002), with the quadratic mean diameter taken at the section nearest 5 metres. Because each group had a relatively low sample size (N=10), the non-parametric Mann-Whitney U-test was performed on each variable to determine significant differences between samples from each infection group ($\alpha = 0.05$). It should be noted that the Mann-Whitney U-test and the Wilcoxon two-samples test yield the same statistic and give the same results (Sokal and Rohlf 1997). To limit the effect of environmental variability, lightly or non-infected and heavily-infected trees were also carefully matched in pairs based on the distance separating them (Figure 1). Nine pairs were formed with a mean distance of 9.49 m (standard deviation = 4.83 m) between lightly or non-infected and heavily-infected trees. A Wilcoxon signed-rank test (Sokal and Rohlf 1997) was used to test for significant differences between infection groups. Paired-sample tests are more powerful than independent-sample tests.

The cumulative dbh, basal area, height and volume average growth curves produced for each tree were compared between infection groups. First, predicted growth curves were modelled for each growth variable and tree using non-linear regression. Best fit to actual cumulative growth curves for each variable and tree were obtained using a three-parameter logistic model of the form:

$$y = \frac{a}{1 + \left(\frac{x}{x_0}\right)^b}$$

where y is the value of the subject growth variable, x is the year of growth, a is the asymptotic level of

growth, b is the growth constant, and x_0 is the inflection point. Because each of these three parameters defines the shape of the growth curves, significant differences between parameters for the two infection groups were determined using the Mann-Whitney U-test ($\alpha = 0.05$). This was repeated for each growth variable. Second, the best three-parameter logistic model was determined for each variable and infection group using the 10 trees as replicates. The resulting predicted growth curves were plotted to age 60. Because trees were not all of the same age and the number of observations decreased with time, only data covering the first 45 years of growth were used in all the regression analyses.

Results

The two infection groups showed no significant difference in age, competition index, dbh, and basal area (Table 1). There was, however, a significant difference in height and form class (Table 1). Specifically, trees in the high infection group were 20.2% shorter and had more stem taper. Both independent- and paired-sample tests yielded divergent results regarding total volume, and when partially controlling for environmental variability no significant difference in total volume was observed as indicated by the Wilcoxon signed-rank test.

The analysis of the coefficients from the logistic regressions derived from each tree in each infection group revealed that the high infection group reached a significantly lower maximum basal area, height, and volume, as predicted by the asymptotic values of the regression model (Table 2). Maximum dbh did not differ significantly between groups. The logistic regression model, projected to age 60, predicts a 21.1% lower basal area (Figure 2B), a 23.4% lower height (Figure 3A), and a 42.1% lower volume (Figure 3B) for the high infection group.

Results showed that there was a significantly higher growth rate for dbh and basal area in the high infection group (Table 2). This was also observed for volume but

TABLE 1: General characteristics of heavily infected and non-infected or lightly infected trees (n = 10 for each group) at time of sampling (Max = Maximum value, Min = Minimum value, SEM = Standard Error of the Mean). The first column of probabilities (**P[1]**) is based on the Mann-Whitney U-test (n=10 for each group). The second column of probabilities (**P[2]**) is based on the Wilcoxon signed-rank test (n=9 pairs).

	Low infection				High infection					
	Max	Min	Mean	SEM	Max	Min	Mean	SEM	P[1]	P[2]
Infestation index	2.0	0.0	1.2	0.29	6.0	4.0	5.2	0.20	**0.000**	**0.007**
Tree age	48.0	42.0	46.3	0.62	82.0	44.0	50.0	3.59	0.728	0.722
Competition index	3.34	0.77	1.85	0.30	1.89	0.66	1.29	0.15	0.257	0.515
Diameter at breast height (cm)	19.20	13.10	16.17	0.38	19.60	11.50	15.45	0.83	0.544	0.515
Basal area (m^2)	0.022	0.012	0.017	0.00	0.024	0.007	0.016	0.00	0.544	0.594
Height (m)	14.10	10.90	12.65	0.39	13.30	8.30	10.10	0.54	**0.004**	**0.008**
Volume (m^3)	0.16	0.09	0.12	0.01	0.17	0.04	0.08	0.01	**0.019**	0.110
Form class	0.83	0.64	0.73	0.02	0.76	0.35	0.56	0.04	**0.004**	**0.008**

TABLE 2. Values of the three parameters of the predicted logistic growth curves used to model diameter at breast height, basal area, height, and volume for heavily infected and non-infected or lightly infected Jack Pine trees (n = 10 for each group). The three parameters are the theoretic maximum (a), growth (b), and the inflection point (x_0) (Max = Maximum value, Min = Minimum value, SEM = Standard Error of the Mean). The first column of probabilities (***P[1]***) is based on the Mann-Whitney U-test (n=10 for each group). The second column of probabilities (***P[2]***) is based on the Wilcoxon signed-rank test (n=9 pairs).

		Low infection group				High infection group					
		Max	Min	Mean	SEM	Max	Min	Mean	SEM	*P[1]*	*P[2]*
Diameter at breast height (cm)	a	22.03	14.12	17.29	0.85	20.97	8.87	13.97	1.21	0.059	0.260
	b	-1.84	-3.30	-2.46	0.13	-2.46	-4.29	-3.26	0.19	**0.005**	**0.015**
	x_0	36.22	23.33	28.46	1.50	28.51	19.23	23.24	1.19	**0.023**	**0.028**
Basal area (m^2)	a	0.071	0.019	0.038	0.0061	0.032	0.007	0.016	0.0026	**0.002**	**0.038**
	b	-2.32	-3.51	-2.84	0.13	-3.07	-5.27	-3.84	0.20	**0.001**	**0.008**
	x_0	93.77	34.64	53.78	5.52	39.18	24.84	31.59	1.72	**0.001**	**0.011**
Height (m)	a	24.37	14.99	19.59	1.01	20.63	9.28	13.90	1.21	**0.008**	**0.015**
	b	-1.71	-2.64	-1.98	0.09	-1.44	-2.65	-2.07	0.12	0.326	0.374
	x_0	42.01	24.38	32.66	1.74	49.34	20.56	27.58	2.71	**0.034**	**0.038**
Volume (m^3)	a	3.237	0.120	0.604	0.297	0.214	0.042	0.097	0.021	**0.001**	**0.015**
	b	-2.98	-4.36	-3.60	0.13	-3.12	-6.07	-4.09	0.25	0.082	**0.028**
	x_0	111.79	40.48	60.48	6.51	48.74	30.68	36.59	1.97	**0.001**	**0.011**

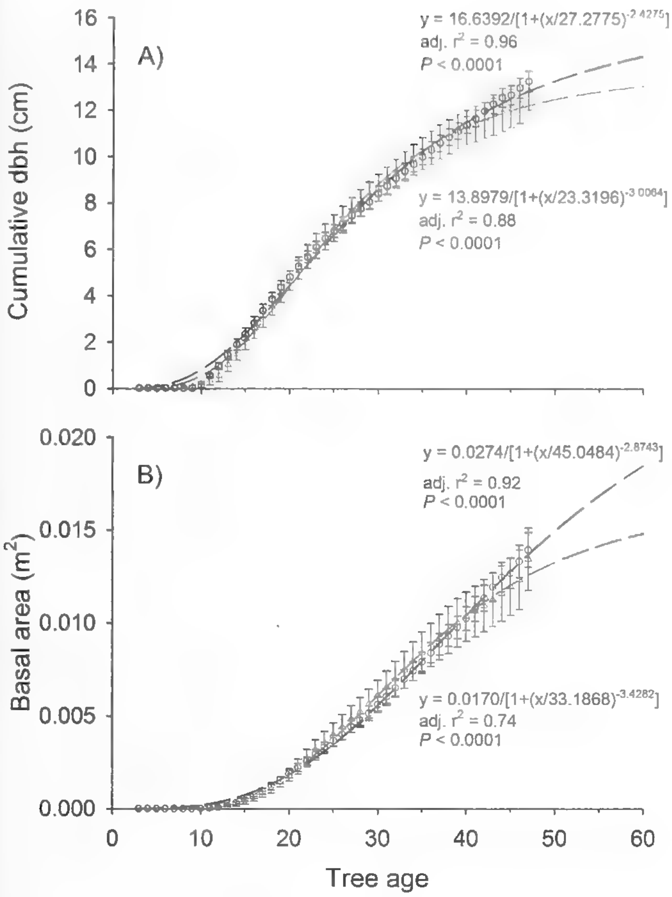

Figure 2: Average cumulative dbh growth (A) and average cumulative basal area growth (B) for each of the two infection groups. Dashed lines represent predicted growth up to year 60 for the infection groups, based on the 3-parameter logistic regression models depicted. Vertical bars represent standard errors of the mean. The black dashed line and empty circles indicates the low infection group, and the dark grey dashed line and empty triangles indicates the high infection group.

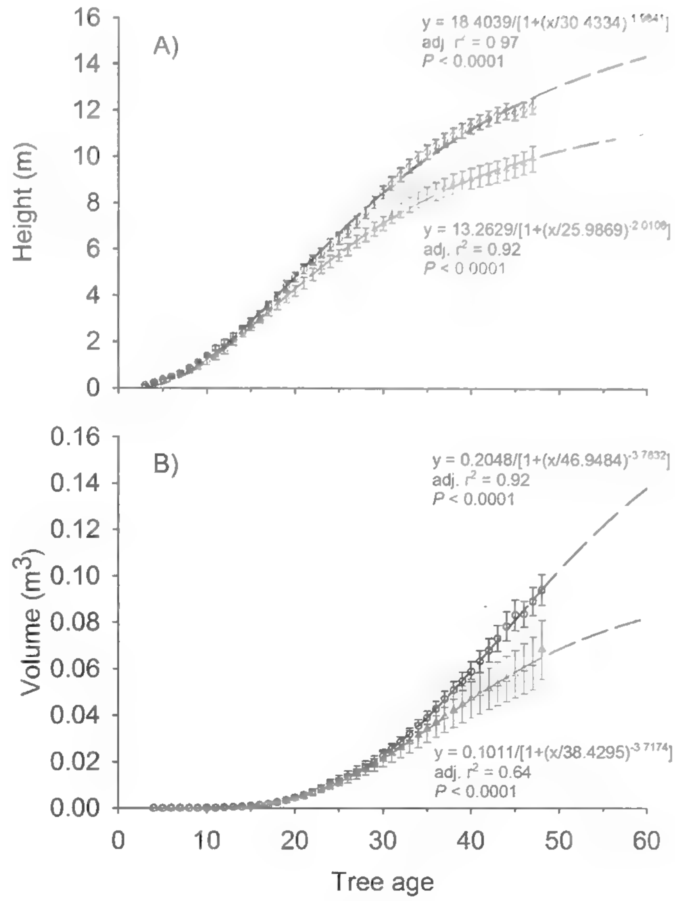

Figure 3: Average cumulative height growth (A) and average cumulative volume growth (B) for each of the two infection groups. Dashed lines represent predicted growth up to year 60 for the infection groups, based on the 3-parameter logistic regression models depicted. Vertical bars represent standard errors of the mean. The black dashed line and empty circles indicates the low infection group, and the dark grey dashed line and empty triangles indicates the high infection group.

only after the Wilcoxon signed-rank test. It should be noted that in a logistic regression, there is an inverse relationship between the growth constant and the actual growth rate. The significantly lower growth constant observed in the high infection group indicates a faster rate of growth. No significant difference in the growth rate for height was observed. However, all four cumulative growth variables of the high infection group reached their inflection point significantly sooner than the low infection group (Table 2), suggesting that the high infection group reached its maximum growth rate sooner. Dbh (Figure 2A) and basal area (Figure 2B) of the two infection groups were not predicted to diverge until after 45 years of age, while height growth curves began to diverge at about 20 years of age (Figure 3A), and volume growth curves began to diverge at 35 to 40 years of age (Figure 3B).

Results indicate a higher level of variability in the basal area and volume of the high-infection group when compared to the low-infection group, as indicated by the lower value of the adjusted r^2 for each logistic regression model. This may indicate variation in environmental conditions at early stages of growth for the trees, or variation in genetic resistance to mistletoe infection. Examination of the stem profiles also revealed that some trees in the high-infection group exhibited little or no evidence of growth reduction despite a high infection index (not presented). These trees could have been recently infected by Dwarf Mistletoe.

Discussion

No significant differences in tree age or competition levels between the two infections groups were observed indicating that Dwarf Misteltoe was was the key factor affecting Jack Pine growth. The lack of a significant difference in dbh between the heavily infected and lightly infected Jack Pine trees at the time of sampling likely reflects the young age of the subject trees and the duration of the infection period. Tinnin et al. (1999) found that there was a significant reduction in the diameter growth of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco var. *menziesii*) heavily infected by *A. douglasii* (infection index = 5 and 6) when compared to non-infected trees (infection index = 0) for trees having mean ages between 78 and 84 years. In Lodgepole Pine, diameter growth was not significantly affected

at stump height, but significant decreases in diameter growth were apparent at heights further up the stem because of greater stem taper (Baranyay and Safranyik 1970). Our study also showed that stem taper was significantly more pronounced in the high infection group.

At the time of sampling, basal area in the high infection group was not significantly different than that of the low infection group. Comparison of the logistic regression coefficients provided similar results to dbh, except that the high infection group was predicted to reach a significantly lower basal area compared to the low infection group as trees continue to grow after age 45. Assuming that basal area increment after the age of 45 years will continue to follow that predicted by the logistic regression model, the projected maximum basal area of the high infection group was approximately 57.9% lower than that of the low infection group. Pierce (1960) also found a 68.5% reduction in basal area for heavily infected Douglas-fir, and a 41.0% reduction in moderately infected Douglas-fir.

Of the significantly affected growth variables, height increment showed a reduction first, i.e., between the ages of 20 and 25 years. Pierce (1960) also found that differences in height were statistically significant between all infection classes, in contrast to diameter. This corresponds with the highly significant 20.2% lower tree height in heavily infected trees in this study. The greater sensitivity of this variable is likely due to the initial response of trees to Dwarf Mistletoe infections. Dwarf Mistletoe infected trees accumulate a high level of biomass in their brooms, which detracts the allocation of resources from biomass production elsewhere in the tree (Tinnin and Knutson 1980). In contrast to the other growth variables, height of the high-infection group had similar variability to the low-infection group, as indicated by similar adjusted r^2 values in the logistic regression curves. This suggests that height growth is less sensitive to temporal changes in factors such as stand density and competition (Avery and Burkhart 2002). Height growth diverged between the two infection groups at a much earlier age than volume, diameter, or basal area, further suggesting that height growth begins to show significant decreases shortly after the development of brooms and loss of apical dominance (Tinnin and Knutson 1980).

At the time of sampling, there was a 33.3% lower average total volume in the high infection group, which was mostly due to a significant reduction in tree height. However, despite early reduction in height growth, volume growth of the heavily infected trees was not significantly affected until 30 to 40 years of age. Our values very closely correspond with those reported by Baranyay and Safranyik (1970), where a group of infected Lodgepole Pine trees with an average age of 37 showed a 35.5% reduction in volume. From the logistic growth model, it was found that the predicted maximum average volume of the high infection group was 83.9% lower than the low infection group. This projected value exceeded the estimated volume reduction in infected stands made by Baker et al. (1992), which was between 53.4% and 70.3% depending on the level of potential crown closure. However, it should be noted that our findings reflected the volume loss in individual trees, and not the volume loss as averaged through an entire stand.

In conclusion, this study confirmed the significance of the impact of Dwarf Mistletoe on the growth of commercial Jack Pine forests, and the potential economic loss due to severe infection. Despite early reduction in height growth, volume growth of the heavily infected trees was not significantly affected until 30 to 40 years of age. Further study on the effects of Dwarf Mistletoe over a wider range of age classes and site indexes would be beneficial in modelling the impact of the parasite.

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Notes

Excavation of an Arctic Fox, *Alopex lagopus*, den by a Polar Bear, *Ursus maritimus*

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Richardson, Evan S., and Ryan K. Brook. 2004. Excavation of an Arctic Fox, *Alopex lagopus*, den by a Polar Bear, *Ursus maritimus*. Canadian Field-Naturalist 118(4): 602-603.

We observed a Polar Bear (*Ursus maritimus*) excavating an Arctic Fox (*Alopex lagopus*) den on 24 June 1998, 3 km inland from the Hudson Bay coast (58°40'N, 93°12'W), near Cape Churchill in Wapusk National Park, Manitoba. To our knowledge this is the first observed excavation of an Arctic Fox den by a Polar Bear.

Key Words: Arctic Fox, *Alopex lagopus*, Polar Bear, *Ursus maritimus*, den, behaviour, Hudson Bay, Wapusk National Park, Manitoba.

The western Hudson Bay Polar Bear (*Ursus maritimus*) population remains on shore from approximately mid-July through early November due to complete annual melting of the sea ice (Stirling et al. 1977). During this period, bears mainly remain relatively inactive (Knudsen 1978; Latour 1981; Lunn and Stirling 1985) and subsist primarily on stored fat reserves (Nelson et al. 1983; Derocher et al. 1990; Ramsay et al. 1991). However, during the summer months, polar bears are opportunistic and occasionally feed on a variety of terrestrial food sources including grasses, sedges and berries (Knudsen 1978; Lunn and Stirling 1985, Derocher et al. 1993), Thick-billed Murres *(Uria lomvia)* (Donaldson et al. 1995), Canada Geese (*Branta canadensis)* (Russell 1975) and their eggs (Smith and Hill 1996), Snow Goose eggs (*Anser caerulescens)* (Abraham et al. 1977), Willow Ptarmigan (*Lagopus lagopus*) (Miller and Woolridge 1983), seabirds (Stempniewicz 1993), microtine rodents (Russell 1975; Miller and Woolridge 1983), and Caribou (*Rangifer tarandus*) remains (Brook and Richardson 2002).

We observed an adult male Polar Bear excavate an Arctic Fox den near Nestor 1 field camp (58°40'N, 93°12'W), near Cape Churchill in Wapusk National Park, Manitoba on 24 June 1998 at 11:00 CST. The bear was initially sighted on a large beach ridge investigating one of the camp buildings and then moved to an Arctic Fox den located approximately 350 m southeast of camp. The bear moved around the site, investigated several of the den entrances and then stopped at one entrance and began to excavate the den. The bear stopped digging every 10 –15 seconds to put its head into the enlarged entrance, continued this behaviour for approximately 3 minutes, then stopped digging and spent approximately 2 minutes investigating several other den entrances, but did not dig them out. The bear then moved away from the den and down the eastern side of the beach ridge, where it could no longer be observed. The bear was not observed eating anything, although while its head was in the entrance, it could not be observed. Several fox pups were occupying the den at the time and we assumed the pups were in the den during the observation although the location of the vixen at the time was unknown. We visited the following day and found a large pit dug by the bear. The excavation was 55 cm at its deepest and was approximately 70 cm wide and 80 cm in length. Arctic Fox pups could still be heard inside the den confirming that the den had not been abandoned and there was no evidence any fox pups were killed. The top of the den was littered with Canada and Snow Goose remains, consisting mostly of feet (98) and other waterfowl remains such as bones and feathers. Cached prey items inside the den were visible from several den entrances and consisted primarily of goose remains. Food remains found at fox dens in the region included both adult and juvenile geese, ducks, Caribou remains and in one instance, a Muskrat (*Ondatra zibethicus*) (Richardson and Brook, personal observations, 1999).

Polar Bears are known to excavate subnivean lairs in search of young Ringed Seal (*Phoca hispida*) pups (Stirling and Archibald 1977). They also excavate earth and snow dens for reproduction, as well as open pits for resting (Clark 1996; Clark et al. 1997). Although adult male bears are known to excavate open pits on coastal beach ridges (Clark 1996), we suggest that the bear was most probably trying to gain access to a potential food source. The bear may have been attracted to the fox den for several reasons. In areas where prey is abundant, Arctic Foxes cache large quantities of food at den sites for later consumption (Sklepkovych and

Montevecchi 1996; Garrott et al. 1984). As a result, other predators may be attracted to den sites by their smell (Prestrud 1992). At active den sites, characteristic barks of arctic fox pups can be heard from within the den when it is disturbed (Eberhardt et al. 1983; Richardson and Brook, personal observations, 1999). Bears are adept at locating food sources by smell (Lunn and Stirling 1985) and it seems unlikely that barking attracted the bear to the site, but the sound may have stimulated further investigation. Prey remains at den sites may provide a direct energy source for bears, however the energetic cost of excavating a den would not likely be repaid in the capture of a small Arctic Fox pup. Although, Macpherson (1969) notes that Arctic Fox dens may be occasionally excavated by Grizzly Bears (*Ursus arctos*) and Wolves (*Canis lupus*), we are not aware of any other published reports of Polar Bears excavating Arctic Fox dens.

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Two Great Black-backed Gulls, *Larus marinus*, Kill Male Longtailed Duck, *Clangula hyemalis*

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Dowsley, Martha, and Andrew Cirtwill. 2004. Two Great Black-backed Gulls, *Larus marinus*, Kill Male Longtailed Duck, *Clangula hyemalis*. Canadian Field-Naturalist 118(4): 604-605.

At Presqu'ile Point, Presqu'ile Provincial Park, Ontario on 23 March 2003, while interpreting the waterfowl migration for park visitors, we witnessed two adult Great Black-backed Gulls attack and kill a male Long-tailed Duck.

Key Words: Great Black-backed Gull, *Larus marinus*, Long-tailed Duck, *Clangula hyemalis*, predation

Great Black-backed Gulls, *Larus marinus*, are known to be scavengers and to take eggs, nestlings, and fledglings of other birds. However, their efficacy as predators is less well documented. On 23 March 2003 we witnessed two adult Great Black-backed Gulls attack and kill a Long-tailed Duck, *Clangula hyemalis*.

We were using a spotting scope (power 45×) to observe diving ducks located 200 to 250 m from shore off Presqu'ile Point, Ontario (44°00'N, 77°41'W) as they fed and rested at the front edge of ice in Presqu'ile Bay. The ducks routinely lifted off when a predatory bird passed overhead. After one such take-off, we observed a pair of adult Great Black-backed Gulls flying above the ducks. One male Long-tailed Duck failed to lift off and the gulls flew down and began to harass it. We did not see the initial separation of the duck from the flock, so we were unable to observe whether it was healthy and merely caught under water when the rest of the flock flew, or whether it was already injured when attacked.

The attack proceeded in what appeared to be a coordinated effort by the gulls. One Great Black-backed Gull flew in circles overhead when the duck dived and swam under water. When the duck surfaced, the gull alighted on the water and tried to bite him. The second gull then took off from the water and flew overhead, watching the duck as he dived again to avoid the attack of the first gull. When the duck resurfaced, the second gull attacked him while the first gull again took off and watched as the duck tried to make another escape under water.

The Great Black-backed Gulls continued to take turns flying and attacking the duck for 20-25 minutes. At the end of this time, one gull succeeded in grabbing the wing of the Long-tailed Duck and both gulls then pecked at the body of the duck. Less than 5 minutes later the duck was dead, and its limp body could be seen floating on the water. The adult Great Black-backed Gulls were then joined by an immature Great Black-backed Gull and all three gulls began to eat the dead duck. We could not continue observations as the wind and currents had pushed the duck's carcass out into Lake Ontario, beyond the useful range of our spotting scope.

Great Black-backed Gulls have a varied diet, but their main food sources are fish and seabirds (both often consumed as carrion) (Buckley 1990). Their predation of birds is focused on the eggs, nestlings, newly fledged young and sick or injured individuals (Beaman 1978; Mawhinney and Diamond 1999). Healthy adult birds are rarely killed, with the notable exception of predation in some seabird colonies, such as those of the Atlantic Puffin (*Fratercula arctica*) in Northern Europe (Beaman 1978), and Newfoundland (Nettleship 1972).

Great Black-backed Gulls are considered to be predators of waterfowl (Good 1998); however, observations of Great Black-backed Gulls attacking and killing adult ducks are quite rare. One notable record reported by Cleghorn (1942) was of an adult Great Black-backed Gull killing a female Goldeneye (*Bucephala clangula*) and an immature Great Black-backed Gull killing another unidentified duck the same day.

Cobb (1957) observed a single adult Great Black-backed Gull kill an injured Ruddy Duck, *Oxyura jamaicensis*, in Rhode Island. In that case the method of attack was similar to what we witnessed at Presqu'ile. The gull hovered above the duck as it dived and then attempted to grab it when it resurfaced (Cobb 1957). Our report corroborates the evidence that Great Black-backed Gulls will fly above diving ducks, presumably to watch them under water, and attack them when they resurface.

Addy (1945) witnessed a group of Great Black-backed Gulls attack and kill an adult American Black Duck, *Anas rubripes*. The gulls chased and swooped at groups of American Black Ducks until one adult gull injured a duck. The gulls then worried the duck by lifting it from the water by its neck and by grasping its back. After about half an hour the duck died, and was consumed, mainly by the gull which had first attacked it (Addy 1945). This observation does not appear to have been a coordinated attack on the duck as in the case we witnessed, because one gull of a group carried out most of the attack and was the primary consumer of the carcass.

In our observation, the two Great Black-backed Gulls showed a level of coordination in their attack that is

unrecorded in the literature. The method they used of taking turns flying overhead and attacking the duck seems to be an efficient means to harass their prey to the point of exhaustion and death.

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First Record of Mountain Lions, *Puma concolor,* in Elk Island National Park, Alberta

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Several sightings of Mountain Lions (*Puma concolor*) and wildlife mortalities consistent with predation by Mountain Lion have occurred in and adjacent to Elk Island National Park from February 2003 to present. These are the first recorded Mountain Lions (locally called Cougar) sightings since the area encompassing the park was protected in 1906.

Key Words: Mountain Lion, Cougar, Puma, Panther, Catamount, *Puma concolor*, Elk Island National Park, Alberta, range, first record.

Along with its current range, Mountain Lion (*Puma concolor*) historically occupied central and eastern Canada (Banfield 1974). In present day Alberta however, Mountain Lion (locally called Cougar) populations are mainly concentrated in the Rocky Mountains and the foothills (Soper 1964; Banfield 1974; Smith 1993; Pattie and Fisher 1999). By 1961, Bird described many large predators, including the Mountain Lion, as being extirpated from the aspen parkland of Canada's prairie provinces. Soper (1964) referenced individual reports of Mountain Lions north of Edmonton, Alberta at Boiler and Grand Rapids on the Athabasca River and in the Peace River Region in northwestern Alberta. He also noted occasional sightings in southern Alberta along the Milk, Bow, and South Saskatchewan River systems, as well as in the Cypress Hills. Smith (1993) added additional sightings near the towns of Whitecourt and Athabasca, Alberta.

Sightings of Mountain Lions are increasing in areas where they were previously unreported. Occasional sightings have been documented to the north in Wood Buffalo National Park (Gau et al. 2001), and to the south and west of Elk Island National Park (EINP) near Cooking Lake, Pigeon Lake, and Sherwood Park (Smith 1979). However, until 2003, there had never been a documented Mountain Lion sighting in EINP (Soper 1940*; Soper 1951; Burns and Cool 1984*; Parks Canada Warden Service unpublished notes). Elk Island lies between longitude W112°57'00" and W112°46'45" and latitude N53°42'57" and N53°30'37" (Figure 1) and covers an area of 196 km^2. The park is located in the Aspen Parkland Natural Subregion (Achuff 1994) in the Beaver Hills of east-central Alberta and is home to several species of large ungulates.

Given the known distances that Mountain Lions would have to travel to access the park, Burns and Cool (1984) predicted "occurrences of cougar in Elk Island National Park [EINP] in future remain a slim possibility". The closest source populations to EINP are in the Rocky Mountains foothills and the Swan Hills region of north-central Alberta (Pattie and Fisher 1999). These populations are approximately 200 km away from EINP, which is well within the 500 km dispersal distance observed for Mountain Lions (Logan and Sweanor 1999).

On 8 February 2003 at 11:00 h one of us observed an adult Mountain Lion approximately 10 km south of the boundary of EINP at Islet Lake in the southern reaches of the Cooking Lake – Blackfoot Grazing, Wildlife and Provincial Recreation Area (Figure 2).

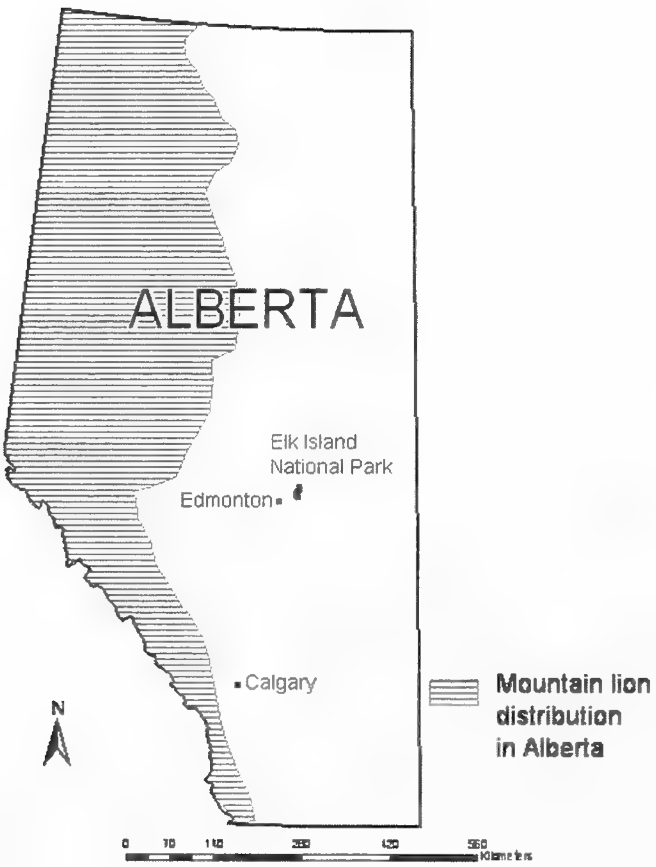

FIGURE 1. Location of Elk Island National Park in east-central Alberta. The shaded area indicates the distribution of Mountain Lion in Alberta (based on Pattie and Fisher 1999).

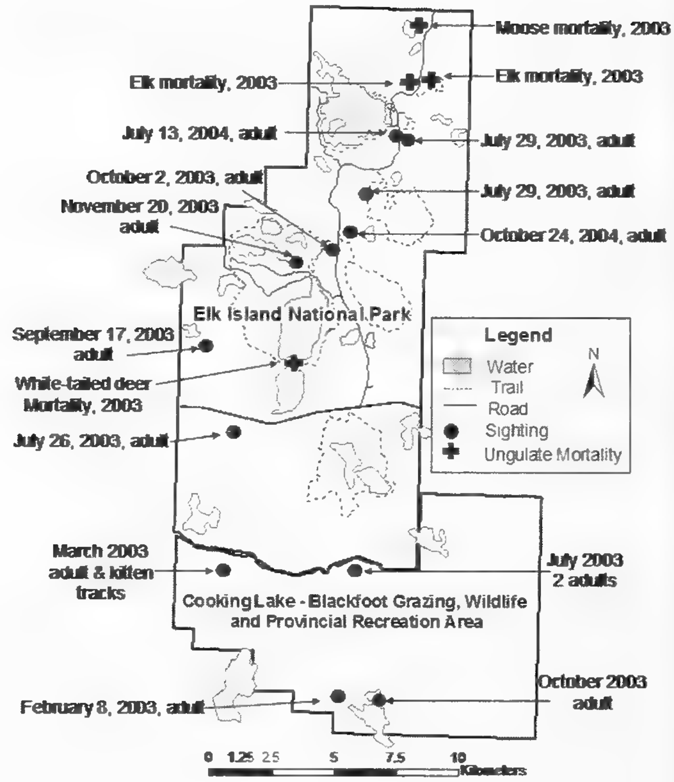

FIGURE 2. Mountain Lion sightings and wildlife mortalities consistent with predation by Mountain Lion in Elk Island National Park and the Cooking Lake – Blackfoot Grazing, Wildlife and Provincial Recreation Area since February 2003.

In late March, a conservation officer found tracks of one large Mountain Lion and a much smaller Mountain Lion together near the northern boundary of the Provincial Recreation Area – an area that bounds the southern extent of EINP. On 26 July 2003 at 14:00 h a group of Young Canada Works students working in the park reported seeing an adult Mountain Lion just south of Highway 16 in the southern half of EINP.

An adult Mountain Lion was also seen by park visitors on two different occasions in the northcentral section of the park on 29 July 2003. The first visitor reported seeing a Mountain Lion at 07:30 h beside the main road through the park and a second visitor saw a Mountain Lion while on a nearby trail at 21:40 h. In the latter case the visitor reported seeing the Mountain Lion watching a herd of Bison (*Bison bison*) approximately 5 km from the trailhead. Equestrians saw two Mountain Lions together in the north central part of the Provincial Recreation Area around the same time.

Further sightings were reported in the fall of 2003 when a park visitor observed an adult Mountain Lion while hiking on 17 September. Another park visitor reported seeing a Mountain Lion cross the main park road on 2 October. In mid-October, a hiker reported seeing a Mountain Lion at the southern part of the Provincial Recreation Area between Push Lake and Islet Lake. On 20 November 2003 a park warden reported seeing a Mountain Lion crossing a secondary road in the east-central part of EINP.

In 2004, a cyclist observed a Mountain Lion sitting beside the main road in the northern part of the park (13 July). The most recent confirmed sighting in the park was on 24 October 2004 when a park resident observed a Mountain Lion in the main part of the park (Figure 2). On two occasions, acreage owners on lands east and north of the park heard estrous calls of a Mountain Lion (October 2003 and August 2004). The landowner who reported the August 2004 calls observed a small Mountain Lion on his property a few days later.

In addition to sightings, four ungulate mortalities with wounds consistent with Mountain Lion predation (Ross et al. 1997) have been documented in the park since the winter of 2002-2003 (Figure 2). Prey species were: 2 American Elk (*Cervus canadensis*), 1 Moose (*Alces alces*), and 1 White-tailed Deer (*Odocoileus virginianus*). In all cases the carcasses had signs of wounds and fatal injuries to the neck and, in some cases, large puncture marks in the hide. Apart from Coyotes (*Canis latrans*), EINP lacks any large resident predators. In addition, the park has very high ungulate densities (approximately 13 ungulates per km^2; Parks Canada unpublished data) and is home to American Elk, Moose, Bison (*Bison bison*), White-tailed Deer, and Mule Deer (*Odocoileus hemionus*). The park also has a large Beaver (*Castor canadensis*) population and many resident medium and small mammal species

including porcupine (*Erethizon dorsatum*), Muskrat (*Ondatra zibethicus*) and Red Squirrel (*Tamiasciurus hudsonicus*). Hare (*Lepus* spp.) are at low densities in the park (Super 1951).

The park provides adequate undeveloped habitat and food resources to support an adult Mountain Lion (Spalding and Lesowski 1971; Ross and Jalkotzy 1992; Ross et al. 1997; Robinson et al. 2002). Currently, park staff translocate Bison and American Elk away from the park to reduce the impact of intense herbivory on vegetation. The presence of large predators, such as Mountain Lions, may help to reduce the ungulate densities in the park, and therefore moderate the amount of active management of ungulate populations by park staff.

The park is completely fenced and the abundance of prey species might offer enough resources to support a future Mountain Lion population. Given that successful reproduction in Mountain Lions is related to the availability of food (Pierce et al. 2000), the likely presence of a mated pair within EINP suggests such a scenario is not unrealistic.

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First Confirmed Occurrence of a Wolf, *Canis lupus,* South of the St. Lawrence River in Over 100 Years

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Villemure, Mario, and Helene Jolicoeur. 2004. First confirmed occurrence of a Wolf, *Canis lupus,* south of the St. Lawrence River in over 100 years. Canadian Field-Naturalist 118(4): 608-610.

A large canid was snared near Sainte-Marguerite-de-Lingwick, Québec, in January 2002. DNA analysis confirmed the animal to be a Wolf *(Canis lupus).* Wolves were extirpated from this region around 1850-1900 and this is the first confirmed observation since then.

Key Words: Wolf, *Canis lupus,* range, dispersal, St. Lawrence River, Québec.

Historically, Wolves *(Canis lupus)* were distributed across most of North America. They were extirpated in the southern portion of their range by the turn of the century (Nowak 1983). In Québec, Wolves disappeared from the south shore of the St. Lawrence River around 1850-1900 (Peterson 1966). The extermination of the Wolf and the development of agriculture in the mid-1900 facilitated the extension of Coyote *(Canis latrans)* range. Wolves are now mostly limited to the northern and less populated regions of North America (Wayne et al. 1992).

On 19 January 2002, a male Wolf was trapped near the village of Sainte-Marguerite-de-Lingwick (45°36'15"N, 71°17'15"W) in the Eastern Townships of southern Québec. The Wolf weighed 29.1 kg, similar to the weight of an adult from Papineau-Labelle (Potvin 1986*) or a yearling from the Laurentides region (Jolicoeur 1998*). A tissue sample was collected from the temporal muscle for genetic identification of the species. DNA analyses were performed by the Natural Resources DNA Profiling and Forensic Center (Trent University, Peterborough, Ontario K9J 7B8 Canada) following the method described in Wilson et al. (2000). The Eastern Townships sample was profiled at the mitochondrial DNA (mtDNA) control region and 8 microsatellite loci. The genetic profile was compared to samples of canids representing the Eastern Wolf (*C. lupus lycaon)* from Algonquin Provincial Park; Western Coyotes (*C. latrans)* from Texas, North Carolina and Ohio; and Wolves (*C. lupus)* from Pukaskwa National Park, northeastern Ontario and the Laurentide Wildlife Reserve region north of Québec City. The above populations were used to compare the Eastern Townships sample against *C. lupus lycaon, C. latrans* and *C. lupus* to assess the species-of-origin or hybrid genotype.

The sample had a mtDNA consistent with *C. l. lycaon/ C. latrans* and the microsatellite genotype suggested 95.0% shared ancestry with Eastern Wolves from Algonquin Provincial Park. The sample had a DNA profile consistent with an Eastern Wolf. The Eastern Wolf is generally described as being smaller than other Gray Wolf subspecies (Nowak 1995, 2002). Although it has been proposed as a distinct species (*C. lycaon)* by Wilson et al. (2000), its status as a subspecies is still generally accepted. Some authors suggest it may result from hybridization between *C. rufus* and *C. lupus* (Nowak 2002). In Québec, the Eastern Wolf is found mostly in the southern deciduous and mixed forests (Jolicoeur and Henault 2002*) Coyote genes found in the mitochondrial DNA of the specimen have been reported before in Wolves in eastern Canada (Lehman et al. 1991; Wilson et al. 2000). Wolves and Coyotes are most likely to interbreed when Wolf density is low relative to Coyotes and when the species are similar in size. In southern Québec, male Coyotes weigh 14.6–18.7 kg (Fortin and Huot 1995*; Dumond and Villard 2000; Villemure 2003*).

Wolf dispersal has been monitored in southern Québec (Messier 1985; Potvin 1987; Jolicoeur 1998*; Villemure 2003*, but Wolves have not been documented crossing the St. Lawrence River. Harrison and Chapin (1998) identified two potential corridors linking Wolf populations north of the St. Lawrence River to potential habitat in Maine and New Hampshire. However, movements of Wolves south of their current range are thought to be unlikely because of potential barriers such as the St. Lawrence Seaway and regions with high human population, high road density and intensive agriculture (Wydeven et al. 1998). Potential core habitat for Wolves has been identified in New England as well as the Eastern Townships and Beauce regions of Québec (Harrison and Chapin 1998; Mladenoff and Sickley 1998; Carroll 2003*; Jolicoeur and Etcheverry, in preparation*).

Wolves are highly mobile and frequently move over long distances (Van Camp and Glukie 1979; Fritts 1983; Mech 1987). Some of the longest dispersal movements documented (460-555 km) occurred across a mixture of forest, farmland, and 4-lane highways in the upper Midwest (Mech et al. 1995; Wydeven et al. 1995). A Wolf in Alberta crossed rivers 0.5 - 2.0 km

wide during summer (Van Camp and Glukie 1979), and Wolves have crossed 24 km on a frozen lake (Mech 1966). Wolves have increased in Minnesota (Fuller et al. 1992), and since the mid-1970s have naturally recolonized portions of northern Wisconsin and, more recently, Upper Michigan (Mech and Nowak 1981; Fuller et al. 1992). Wolves from Canada have recolonized Montana for at least the past decade (Boyd et al. 1995). In a review of Wolf dispersal and recolonization, Wydeven et al. (1998) reported that 31 to 63% of dispersing Wolves successfully settled and formed pairs in new territories.

It is unclear whether Wolves have begun re-establishing in the Eastern Townships, or whether this Wolf was simply a dispersing individual. While the Eastern Townships may be a sink habitat for Wolves, this Wolf was caught only 30-50 km from potential Wolf habitat in Maine (Carroll 2003*). Further investigation is necessary to confirm other possible Wolf observations in these regions. Reporting of Wolf sightings or accidental Wolf captures south of the St Lawrence river should be encouraged.

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Is Cost of Locomotion the Reason for Prolonged Nesting Forays of Snapping Turtles, *Chelydra serpentina*?

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Prolonged nesting forays were observed in five gravid Snapping Turtles *(Chelydra serpentina)*, in 1999 and 2001. For all observations, the females began exploratory nest excavations but failed to oviposit. Subsequently, all five females sought refuge either by burying themselves in substrate, or by seeking shade under vegetation, presumably to wait until the following day to resume nesting activities. By contrast, most observations of failed nesting resulted in the females abandoning the nesting site and returning immediately to water. Although prolonged nesting attempts in other turtle species (i.e. kinosternids) likely are associated with rainfall or predation risk, we speculate that these prolonged nesting attempts in Snapping Turtles reduced the cost of terrestrial travel.

Key Words: Snapping Turtles, *Chelydra serpentina*, oviposition, nesting behaviour, cost of locomotion, Ontario

Nesting behaviour of Snapping Turtles (*Chelydra serpentina*) has been described in detail elsewhere (see Ernst et al. 1994), and is generally characterized by behaviour that minimizes exposure on terrestrial habitats. Briefly, nesting behaviour starts with emergence from water, followed by nest site selection. Females typically dig with their front limbs, and often poke their noses into the substrate, presumably to determine if the soil type and/or hydration are adequate. Subsequently, the rear limbs are used first to excavate the nest cavity, then position the eggs during oviposition, and finally to bury the eggs. Subsequently, the female leaves the nesting area, and returns to the water. Although Snapping Turtles have been known to travel more than 0.5 km overland to nesting sites (Obbard and Brooks 1980), normally they nest at a site much closer to the water. Regardless if the female was successful in nesting or not, generally she returns to water immediately afterwards. Nesting normally occurs in the early morning or late evening, although females may nest in the afternoon following rain. By minimizing the distance or time traveled on land, female Snapping Turtles may avoid energetic costs, or the risks of dehydration or predation. Baudinette et al. (2000) found that terrestrial locomotion was 2.6 times more energetically costly than aquatic locomotion for the Murray Short-necked Turtle (*Emydura macquarii*). Snapping Turtles are particularly vulnerable to water loss compared to other turtles (Ernst 1968) due to their exposed skin. Although depredation of adults is rare, adult females are occasionally taken by large predators, such as bears or coyotes (Ernst et al. 1994). Here we document five instances of prolonged nesting forays in Snapping Turtles, which have not previously been documented, and discuss possible reasons for this behaviour.

Study Site

Observations were made from two locations in Ontario, both known for many years to be nesting sites for Snapping Turtles. The first nesting site, the northwestern shoreline of Coote's Paradise, Hamilton (43°16'N, 79°56'W), consists primarily of a community vegetable garden and a wood chip pile on Ontario Power Generation property. The nesting site is separated from the open water by approximately 150 m,

first by a steep hill with thick shrub cover, and secondly by dense cattails. The second nesting site, at Wheatley Provincial Park (42°5'N, 82°26'W), consists of a series of sand, dirt, and wood chip piles in a maintenance area. Although normally open water is relatively close to the nesting site (~ 50 m), in 2001 when the observations were made, water levels were extremely low, and most water in the park had drained into Lake Erie, leaving bare mudflats. We observed many turtle tracks in the exposed mud leaving the park into Lake Erie (de Solla, personal observation). Thus, at both sites, the nesting females did not have nearby access to water.

Nesting Observations

De Solla et al. (2001) reported the deaths of two gravid Snapping Turtles that buried themselves in a composting wood chip pile at Cootes Paradise, Hamilton, on 7 and 9 June 1999. Both gravid turtles remained in the wood chip pile until their deaths. Results of post-mortem examinations were consistent with death due to hyperthermia (de Solla et al. 2001); however, no reasons for their behaviour were suggested. The behaviour of both females was consistent for females searching for suitable nesting sites, except after failing to successfully nest, both buried themselves in the wood chip pile. A third female Snapping Turtle was also observed 8 June 1999 on the wood chip pile. Following apparently unsuccessful attempts to nest, the female was observed to be motionless for a few hours under the shade of burdock (*Arctium* spp.) and other vegetation, which provided the only shade in the area. De Solla did not touch her until later in the morning, but the turtle was found to be gravid. She remained in the shade after being disturbed.

On 9 June 2001 at 1045, a female turtle was found on a storage area for sand, dirt, and wood chips at Wheatley Provincial Park. There were numerous tracks on both the wood chips and dirt piles, possibly by more than one female. There was abundant shade at this site. She was sitting in shade under vegetation on a small dirt pile, with no apparent movement, and no evidence of nesting. She was left alone until 1200, at which time the female was about 2 m from her previous location, further in shade under vegetation. She did not move by 1300. At this time she was palpated, found to be still gravid, and a blood sample was taken. She was released at the same spot she was found, where she remained for at least one hour, but she was not subsequently observed. No temperature readings were taken; however, the weather was sunny and hot.

On 12 June 2002, a female was seen in the vegetable garden at Coote's Paradise at approximately 2130. Nearby were at least 10 digging attempts in freshly cultivated soil, and she was observed digging with her front limbs and poking her head into the soil. She was observed for approximately an hour, but did not show any signs of nesting. At approximately 2230, she was observed to have buried herself, with only the top of her carapace showing. There was relatively little shade by vegetation available. At approximately 0745 hrs, 13 June 2002, a female was seen walking very near where the female from the previous night was observed. This female was heavily covered with dirt, suggesting that she was the same female that had buried herself. No nesting attempts were made by 1000 hrs; subsequently we left and she was not observed again.

Discussion

The five observations of nesting attempts by Snapping Turtles had two common features; the delay was prior to oviposition, and the turtles sought terrestrial refuge by burying themselves in soil or wood chips, or by staying in shade. We have no observations of females remaining at the nesting ground after successful oviposition. We are unaware of any published reports of such behaviour in Snapping Turtles.

Various kinosternid species prolong their nesting forays, typically by burying themselves before and/or after oviposition (Iverson 1990; Burke et al. 1994; Wilson et al. 1999) adjacent to the nest. The duration of nest attendance in species other than *Chelydra* appears to be linked to the timing or duration of rainfall (Burke et al. 1994; Ernst et al. 1994). Intensive disturbance may also delay successful oviposition, and competitive nesting by Green Turtles (*Chelonia mydas*) at high densities may delay oviposition by a few days (Jessop et al. 1999). Typically, after a failed nesting attempt Snapping Turtles return to the wetland immediately following cessation of nesting behaviour (de Solla, persional observation).

We speculate that the prolonged nesting attempts we observed in Snapping Turtles was to avoid the cost of making a second trip between the water and nesting site. All instances of prolonged nesting attempts that we observed occurred a considerable distance from water. Abandoning a nesting attempt would therefore result in a relatively long journey to the water, and back again to the nest site for a second oviposition attempt. To avoid this cost, once a female aborts a nesting attempt, she may burrow under substrate or hide under vegetation until the following day. Females nesting closer to wetlands are more likely to leave the nest site and come back at a later time. At the Wildlife Research Station (Algonquin Park), Snapping Turtle nesting has been monitored on a dam at the southern end of Lake Sasajewun for > 25 years, and all observed nesting attempts that failed were followed by the immediate withdrawal to the water (~ 5 m) by the female (R. J. Brooks, University of Guelph, personal communication). Similarly, at eight other nesting sites in Ontario that the authors visited, all of which were close to wetland habitat, females withdrew to water following a failed nesting attempt. We did not count the number of these observations, but de Solla has frequently observed this behaviour.

In two of the five observations of prolonged nesting attempts, the turtles died of hyperthermia after burying themselves in composting wood chips (de Solla et al. (2001). We speculate that in most cases where females bury themselves, they use non-composting material, and thus are not at risk of hyperthermia.

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Significant Vascular Plant Records from the Hamilton Area, Ontario

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Four additions to the known vascular flora of Ontario (*Aesculus pavia, Ambrosia* × *helenae, Anthriscus caucalis, Verbena bonariensis*) and ten other provincially significant records are discussed. Of the 14 taxa listed, two (*Actaea* × *ludovici* and *Ambrosia* × *helenae*) are native.

Key Words: adventive species, flora, rare species, distribution, Hamilton, Halton, Ontario.

Field and herbarium work centred around Royal Botanical Gardens on the border between Hamilton and Burlington, Ontario (43°29.00'N, 79°88.00'W), has resulted in the following 16 provincially significant vascular plant records in 2002. For locally significant records, see Rothfels (2003). All records are supported by specimens in the Royal Botanical Gardens herbarium (HAM).

Taxa preceded by an asterisk (*) are not native to the Hamilton Region. Taxon names are followed by their subnational rank (Srank) as of 1998, where applicable (see Newmaster et al. 1998). An Srank of S1 indicates a very rare native taxon, with generally five or fewer occurrences in Ontario; a rank of SE1 is similar, but refers to a non-native taxon; and a rank of SEH (historical) indicates a non-native species that has typically not been recorded in Ontario in the past 20 years (Newmaster et al. 1998). The names used follow Kartesz and Meacham (1999*).

Actaea × *ludovici* B.Boivin. **Hybrid Baneberry** S1 RANUNCULACEAE

One clump of this hybrid was collected from the Devil's Punchbowl Environmentally Significant Area, in Hamilton (43°11.80'N, 79°38.50'W). Both parental species (*Actaea rubra* (Aiton) Willd. and *Actaea pachypoda* Ell.) were in close proximity. Despite the overlapping ranges of the parental taxa, the hybrid is rare (Voss 1985), perhaps due to differing phenology (Pringle, personal communication). In Canada, it is recorded from Ontario and Quebec (Kartesz and Meacham 1999*). (*C. J. Rothfels 305*).

* *Aesculus pavia* L. **Red Buckeye** HIPPOCASTANACEAE

This species is an addition to the flora of Ontario (Newmaster et al. 1998). Over ten young trees were found naturalized in the Red Hill Creek escarpment valley, City of Hamilton, by Megan Ogilvie and Albert Garofalo. These plants are likely spreading from trees

planted in 1927 (Bruce Duncan, personal communication). A species of the southern United States, it reaches its northern limit in Kentucky, West Virginia, and southern Illinois (Kartesz and Meacham 1999*). It differs from *A. glabra* Willd. and *A. hippocastanum* L., the other two species reported from Ontario, by its smooth fruit (Edmondson 1997), among other features. It is, due to its reddish flowers, perhaps most likely to be confused with the frequently-planted *Aesculus ×carnea* Hayne, which differs in its size (*A. pavia* is a small tree or large shrub, *A. ×carnea* is a large tree), leaf shape (*A. pavia* has lanceolate leaves unlike the obovate leaves of *A. ×carnea*) and petal shape (*A. pavia* has dissimilar petals with two broad lateral petals and two long-stalked spoon-shaped petals; all petals of *A. ×carnea* are large and shaggy) (Krussman 1984). (*M. Ogilvie, A .Garofalo et al. s.n.*; HAM 16221).

* *Aethusa cynapium* L. **Fool's-parsley** SE1 APIACEAE

This species was found new for both the City of Hamilton (Goodban 1995) and Lambton County (Tiedje and Tiedje 2002) in 2002. In Hamilton, it is fairly common along wooded paths along the base of the Niagara Escarpment in the Devil's Punchbowl Environmentally Significant Area (43°12.20'N, 79°40.70'W). The Hamilton specimen was determined only to the specific level. The Lambton County specimen was determined as *A. cynapium* ssp. *cynapioides* (M. Bieb.) Nyman, the larger woodland subspecies (using Tutin 1968) and it was common on the Ausable River floodplain in the Rock Glen Conservation Area (43°05.10'N, 81°06.80'W). *Aethusa cynapium* has been found in the Great Lakes States, and in Quebec, New Brunswick, and Nova Scotia (Kartesz and Meacham 1999*). The early Canadian reports describe this species as a garden weed "introduced with garden seeds from Europe" (Macoun 1883), and list it from Hastings and Northumberland Counties in Ontario, and as "occasional" in New Brunswick (Macoun 1883). (*J. Rothfels & J. Shearer 243*; *C. J. Rothfels 274*).

* *Amaranthus blitum* L. **Purplish Amaranth** SEH AMARANTHACEAE

This species is new for Halton Region (Varga et al. 2000). A purple-leaved amaranth, it is scattered irregularly in the lawns at Royal Botanical Gardens Centre (43°17.40'N, 79°59.70'W) where it appears to be dispersed by Canada Geese. Scoggan (1978) reports this species as introduced in waste ground in Elgin County, Huron County, and Waterloo Regional Municipality in Ontario, and from Masson, Montreal and Quebec City in Quebec. (*C. J. Rothfels & D. Gugler 303*).

Ambrosia × helenae Rouleau **Hybrid Ragweed** ASTERACEAE

This taxon is an addition to the flora of Ontario (Newmaster et al. 1998). It is a hybrid between Common Ragweed (*Ambrosia artemisiifolia* L.) and Giant Ragweed (*Ambrosia trifida* L.). Although the ranges of these two species overlap frequently, the hybrid is very rare (Wagner 1958). It was collected along the north shore trails of the Cootes Paradise Nature Sanctuary in Hamilton (43°16.90'N, 79°54.10'W). The type locality is in Quebec (Wagner 1958), and it has also been found in Michigan, New York State, and Ohio (Kartesz and Meacham 1999*). (*D. Gugler s.n.*: HAM 15959).

* *Anthriscus caucalis* M. Bieb. **Bur-chervil** APIACEAE

This species is an addition to the flora of Ontario (Newmaster et al. 1998). It was abundant on disturbed ground near the Royal Botanical Gardens' Laking Garden (43°17.50'N, 79°53.30'W). Shortly after the discovery, the site was mowed by the owner. This species is known in Canada only from Nova Scotia, but is scattered widely across the United States (Kartesz and Meacham 1999*), and is easily distinguished from its more common congener (*A. sylvestris* (L.) Hoffm.) by the hooked hairs on the fruit (e.g., Gleason and Cronquist 1991). (*C. J. Rothfels & J. L. Reader* 115).

* *Anthyllis vulneraria* L. **Lady's-fingers** SE1 FABACEAE

This species is new for the City of Hamilton (Goodban 1995). It was fairly common, but local, in disturbed, weedy, poorly drained ground (a pipeline right of way) in the Beverly Swamp Environmentally Significant Area (43°21.10'N, 80°06.80'W). It has been reported from British Columbia, Ontario, Quebec, Newfoundland, and New Brunswick (Kartesz and Meacham 1999*). Scoggan (1978) notes that it is "locally introduced into clover fields and waste places," a description that concords closely with this report, and lists records from Oxford, Waterloo and Wellington Counties in Ontario, from "slaty banks of the Restigouche River near Matapedia" in Quebec, and from Newcastle in New Brunswick. (*C. J. Rothfels 143*).

* *Cardamine impatiens* L. **Narrow-leaved Bittercress** SE1 BRASSICACEAE

This species is new for the City of Hamilton (Goodban 1995). Four plants were found along the north shore of the Cootes Paradise Nature Sanctuary, near a small boat-storage facility, along a partially disturbed forest edge (43°16.90'N, 79°54.00'W). This is an upright *Cardamine*, with distinctly auriculate pinnately-divided leaves (e.g. Voss 1985). Mulligan (2002) only saw a single Canadian specimen, collected by J. M. Weber in 1980 for Port Credit, Ontario, and notes that this species is "sporadic and uncommon" in the United States. This species was not listed by Scoggan (1978). (*C. J. Rothfels 88*).

* *Coronopus didymus* (L.) J.E.Sm. **Lesser Wart-cress** SE1 BRASSICACEAE

This strange little mustard is new for the City of Hamilton (Goodban 1995). It is a common weed in some of the Royal Botanical Gardens' Rock Garden

flower beds (43°17.20'N, 79°53.60'W). This is the second confirmed record for Ontario (Oldham personal communication). It first established a foothold in the east — Scoggan (1978) lists five counties in Nova Scotia and two in New Brunswick containing this species — but it also occurs across the country (a single record each in British Columbia, Alberta, Quebec, and Newfoundland (Scoggan 1978). The first Canadian records are from Gaspé Basin, Quebec, and North Sidney, Nova Scotia, in 1862 and 1883, respectively (Mulligan 2002). *Coronopus didymus* can be differentiated from *Coronopus squamatus* (Forssk.) Aschers. (which is also weedy) by its wrinkled cordate fruits that are notched at the summit. The fruits of *C. squamatus* are conspicuously apiculate at the summit (e.g. Holmgren 1998). (*C. J. Rothfels 71*).

* *Euonymus fortunei* (Turcz.) Hand.-Mazz. **Wall-creeper** SE1 CELASTRACEAE

This species has been known from Royal Botanical Gardens' sanctuary lands for several years (Smith 2003), but has not been collected until this year. It is widespread but local in the Cootes Paradise Nature Sanctuary, where it occasionally forms small dense patches on the oak-hickory slopes (43°1620'N, 79°55.10'W). It seems to be increasing in southern Ontario, and may become a problem in some natural areas (Oldham, personal communication 2003). *(C. J. Rothfels 235).*

* *Macleaya cordata* (Willd.) R. Br. **Plume-poppy** SEH PAPAVERACEAE

This species is new for the City of Hamilton (Goodban 1995). This large plant is occasionally planted as an ornamental. Its occurrence on the east shore of the Cootes Paradise Nature Sanctuary (43°16.80'N, 79°53.50'W) is mysterious; it could be a persistent population from some unknown source or it could be "spontaneous". Voss (1985) describes it as "seldom escaping" in Michigan, and Scoggan (1978) lists it as a "garden escape" that is "scarcely established" in Norfolk County in Ontario and Missisquoi County in Quebec. (*C. J. Rothfels 318*).

* *Myrrhis odorata* (L.) Scop. **Scented Myrrhis** SE1 APIACEAE

This large umbellifer is new for Halton Region (Varga et al. 2002). It is escaping from the Royal Botanical Gardens' Scented Garden into the neighboring ravines (43°17.50'N, 79°52.60'W). Currently, its spread is limited, and will be tracked in future years. It is reported from two other Ontario locations: St. Thomas, Elgin County, and Manitoulin Island, Manitoulin District (Pringle 1994); as well as from British Columbia, Nova Scotia, Michigan, Pennsylvania, and Oregon (Kartesz and Meacham 1999*). The smooth fruit and large size help differentiate this species from the native *Osmorhiza* species (Pringle 1994). (*C. J. Rothfels 190*).

* *Sorghum bicolor* (L.) Moench ssp. *bicolor.* **Sorghum** SE1 POACEAE

This species is new for the City of Hamilton (Goodban 1995). It was common with other weeds on freshly disturbed ground at the Royal Botanical Gardens' outdoor compost facility (43°17.10'N, 79°53.70'W). It has been found in Quebec and most U.S. states, and is a noxious weed in three states (Kartesz and Meacham 1999). (*C. J. Rothfels 317*).

* *Verbena bonariensis* L. **Purpletop Vervain** VERBENACEAE

This species is an addition to the flora of Ontario (Newmaster et al. 1998). One plant was found on the Osprey Marsh Christmas tree carp barrier (a row of old Christmas trees erected in the mud to prevent carp from travelling from Grindstone Creek into Osprey Marsh), in the Hendrie Valley Nature Sanctuary, Halton Region (43°17.40'N, 79°52.90'W). It might have arrived in the treads of the machinery used to place the trees in the winter. This species is not in the Royal Botanical Gardens' cultivated plants database, and thus has theoretically never been planted on RBG property. One individual of this species was seen at the Childrens' Garden in Westdale (not operated by RBG) in 2002, approximately 3.5 km from the Osprey Marsh population. This species is introduced to the southern States, and has also been reported from Oregon, New York State, New Jersey, and New Hampshire (Kartesz and Meacham 1999*). It has not been reported from Canada. (*C. J. Rothfels & I. Vaithilingam* 435). A previously-overlooked specimen was also uncovered at HAM. It is an undated specimen from a "river bank" at "Lake Erie," and was identified by J. S. Pringle in 1964 (*K. Stanley s.n.*). In light of the 2002 discovery, it seems reasonable that this record could also have been "spontaneous".

Discussion

The eight taxa found new for Hamilton add to the current published list of 1304 species (Goodban 1995), and the four new taxa for Halton bring that region's tally to 1305 (Varga et al 2000). Additionally, four of the taxa are new for Ontario. Twelve of the fourteen records discussed are non-native occurrences, several of which, especially *Aethusa cynapium, Euonymus fortunei*, and *Sorghum bicolor,* should be watched for invasive tendencies.

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Thanks to Jim Pringle for assistance in the determination of *Aethusa cynapium*, *Amaranthus blitum*, *Anthriscus caucalis*, *Cardamine impatiens*, *Coronopus didymus*, and *Macleaya cordata*; thanks to Jim Pringle and Michael J. Oldham for helpful earlier reviews of this manuscript, and to Megan Ogilvie, Albert Garofalo and Dean Gugler for submitting their records. Contribution from Royal Botanical Gardens Number 114.

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Do Rhinoceros Auklet, *Cerorhinca monocerata*, Fledglings Fly to the Sea from Their Natal Burrows?

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Hayward, James L., and Jere K. Clayburn. 2004. Do Rhinoceros Auklet, *Cerorhinca moncerata*, fledglings fly to the sea from their natal burrows? Canadian Field-Naturalist 118(4): 615-617.

The mode of departure of Rhinoceros Auklet fledglings from their nest burrows has remained uncertain. Both walk-down and fly-down hypotheses have been proposed. Here we use the unique geography of Protection Island, Washington, to evaluate the fly-down hypothesis. Some fledglings raised on Protection Island do appear to walk to the water, but our results suggest that many of the island's fledgling Rhinoceros Auklets fly to the sea.

Key Words: Rhinoceros Auklet, *Cerorhinca monocerata,* fledgling departure, Washington.

Rhinoceros Auklets (*Cerorhinca monocerata*) are the most abundant puffins in the waters of the Pacific Northwest. Unlike Tufted and Horned puffins (*Fratercula cirrhata* and *F. corniculata*, respectively), which also breed along western North America, members of most populations of Rhinoceros Auklets leave their nesting colonies before dawn to feed and return after sunset (Wilson and Manuwal 1986; but see Thoresen 1980). Consequently, some basic information on the behavior of these birds remains obscure, despite growing knowledge of their breeding biology (Richardson 1961; Scott et al. 1974; Leschner 1976; Summers and Drent 1979; Vermeer 1978, 1979, 1980; Thoresen 1980, 1983; Wilson and Manuwal 1986; Wilson 1993; Gaston and Duchesne 1996).

One elusive piece of information involves the mode of departure from nest sites by newly-fledged Rhinoceros Auklets. Young Atlantic Puffins (*F. arctica*) walk,

flutter, or fly to the water from their burrows (Lockley 1934; Richardson 1961; Gaston and Jones 1998), whereas fledgling Cassin's Auklets (*Ptychoramphus aleuticus*) fly to the sea after making short "practice flights" (Manuwal 1974). Leschner (1976) found Rhinoceros Auklet fledglings that were too small to fly "crouched under rocks or crevices in the morning" on Destruction Island, Washington; this suggested to her "that fledglings walk or flutter to the water." Similarly, Wilson (1977) observed fledgling Rhinoceros Auklets on Protection Island, Washington, "walking down the grass covered slopes" to the sea. But Richardson, (1961) who also worked on Protection Island, wrote that "flight [capability] … appears to develop precociously," and that like the "half-grown young" of murres, fledgling Rhinoceros Auklets "fly down to the water."

On Protection Island, hundreds of Rhinoceros Auklets nest along a sandy cliff that rises above Violet Point, a gravel spit that contains a large Glaucous-winged Gull (*Larus glaucescens*) colony. Each summer, scores of auklet fledglings are found dead within a relatively defined area of the gull colony, across an artificial channel and marina from the cliff. The distribution of dead fledglings and the unique semi-natural geography of Protection Island allowed us to evaluate Richardson's fly-down hypothesis.

Methods

Protection Island, Jefferson County, Washington (48°08'N, 122°55'W), consists of a 35–76-m high plateau surrounded by steep, grass-covered, sandy cliffs ideally suited for Rhinoceros Auklet burrowing. The largest Rhinoceros Auklet colony in Washington is located here, with approximately 27 549 burrows (Wilson and Manuwal 1986). Violet Point, a gravel spit that extends 800 m east from the upper island, contained around 5 100 of Glaucous-winged Gull nests during this study (J. G. Galusha, personal communication).

In July and August 1992, 1993, and 1997 the location of each auklet fledgling found dead on Violet Point was plotted by measuring its north or south distance from a transect that measured its eastward distance from the base of the island's east-facing cliff. To estimate age at death, culmen and tarsal lengths, if still present, were measured in 1992 and 1993. The height of the highest (60 m) nesting burrows on the cliff in relation to the distribution of dead fledglings on Violet Point was used to approximate a range of presumed fledgling flight path angles trigonometrically.

Results

One hundred and twenty-one dead fledglings (43 in 1992, 11 in 1993, and 67 in 1997) were counted between 106 m east of the cliff base, at the western margin of the gull colony, and 398 m east of the cliff base, toward the center of the gull colony (Figure 1). The fledglings apparently died as a result of hitting the spit or being attacked by resident gulls. No dead fledglings were found beyond 398 m. The pooled mean (± SD here and below) distance of fledgling corpses from the base of the nest cliff was 303 ± 58.0 m (n = 54, range = 106-398 m). Mean culmen length was 24.4 ± 3.0 mm (n = 35), and mean tarsus length was 37.9 ± 1.6 mm (n = 48); Rhinoceros Auklets of this size are about 45 days old (Wilson and Manuwal 1986). During late July and early August, we occasionally found live Rhinoceros Auklet fledglings hiding in grass between the nesting cliff and the channel/marina, and we regularly observed fledglings swimming in the water of the marina/channel.

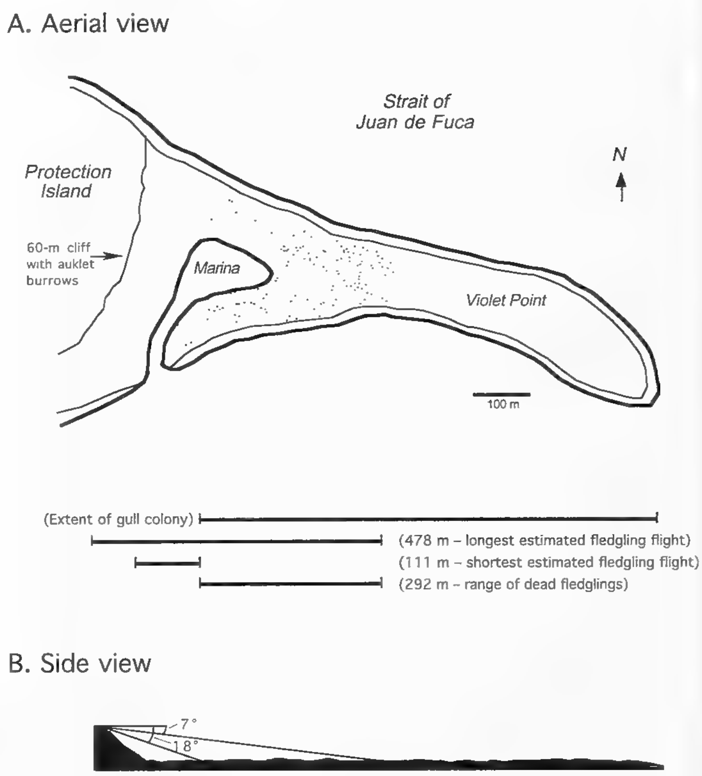

FIGURE 1. A. Aerial view of Violet Point, Protection Island, Washington. Dots indicate locations of dead fledgling Rhinoceros Auklets found during July and August, 1992, 1993, and 1997. Lines below indicate approximate extent of the spit occupied by the gull colony, extent of fledgling auklet corpses, and estimated extents of fledgling auklet flight distances. B. Side view of Violet Point showing the estimated range of Rhinoceros Auklet fledgling flight paths, sloping from 7°–18° from the highest (60 m) natal burrows above the gull colony; fledgling flights from lower burrows would exhibit progressively shallower angles.

Discussion

Large numbers of dead fledglings found in gull territories east of the marina/channel water and across from the nesting cliff support the hypothesis that these fledglings flew down and over the water from their natal burrows. Alternate means of reaching the east side of the marina/channel were highly unlikely: (1) walk/flutter down slope, enter the marina/channel water from the west shore, leave the water on the east shore, enter the gull colony, be killed; (2) walk/flutter

down slope, enter the colony north of the marina/channel, walk/flutter through a gauntlet of gull territories to the east side of the water, be killed; (3) walk/flutter down slope, enter the colony north of the marina/channel, be killed, then be transported to distant points east of the water by gulls. With respect to (3), it should be noted that fledging Rhinoceros Auklets exhibit an average mass of 360 g (Wilson and Manuwal 1986), 34% of the average mass of 1051 g (Vermeer 1963) for adult Glaucous-winged Gulls in this region; thus it appears unlikely that auklet corpses could be moved very far from the place where they were killed.

Our data, with those of Richardson (1961), Leschner (1976), Wilson (1977), and Wilson and Manuwal (1986), support the following scenario for the departure of fledgling Rhinoceros Auklets from their nest burrows on Protection Island: In late July and early August, some fledgling auklets walk and flutter, but also many fly directly away from their natal burrows. Fledglings cannot sustain prolonged flight, however, and from the highest nests lose altitude at a rate of 13–32 m/100-m distance, with a slope of 7°–18° (Figure 1B); fledgling flights from lower burrows would exhibit progressively shallower angles. Fledglings from preferred nest sites located directly above the ocean (Richardson 1961) reach the water successfully. Fledglings that fly from nest sites along the cliff above Violet Point hit the gull colony where they are killed, unless they veer to the ocean or are fortunate enough to land in the marina/channel. Whether this scenario applies to fledgling departures at other Rhinoceros Auklet colonies remains unknown.

Acknowledgments

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A Tribute to Thomas Henry Manning 1911-1998

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I first met Tom Manning on his Merrickville farm in the spring of 1965, during lambing time. Andrew and Betty Macpherson who had both travelled with him in the Arctic, brought me out to see Arctic Foxes. These captive animals were part of a research program on the influence of light on moult timing. On the way to. Merrickville, I listened to their stories about Tom's legendary explorations and scientific expeditions. I was therefore prepared for the prospect of meeting an Arctic hero. Instead, I found a quiet, stocky man in his fifties, dressed in faded and ragged overalls tending his sheep. The stub of a hand-rolled cigarette hung from his lower lip – perpetually unlit. He did not seem pleased at extra company and bluntly asked why I had been brought out. Later, over glasses of his lethal home-made cider, I realized that here was a man who was much more than he seemed. By the end of that day we had become firm friends – a friendship that was to last until his death in November of 1998.

Few knew Tom Manning well; and few indeed were given a chance to comprehend, as a whole, the complexity and sheer bulk of his phenomenal life's work. Except for a very few close friends, Tom was deeply private, and even withdrawn. He was a relentless and dogged scientist who spared no effort to find either the original source of any information, or to redo any questionable measurements – even if they were his own. Applying his logical and inquiring mind to all kinds of life-forms, natural phenomena and expedition challenges, Tom also had the skill, intuition and knowledge to assess and react appropriately in critical situations. He did so with a rapidity I found astonishing. His mental brilliance, awesome physical endurance, good looks and charm, combined with great modesty and fondness for red sportscars, contributed to a remarkable personality.

On the 22 of December, 1911, Thomas Henry Manning was born into a gentleman's life. Even as an infant, he defied prediction and showed his amazing capacity for endurance. Except for a surgeon who "did not want to commit murder on Christmas Day" and reluctantly operated, Tom might soon have died, a victim of pyloric stenosis. Tom was the only child of Dorothy (nee Randall) whose brother was the last gentleman jockey in England, and Thomas Edward Manning, (TEM) who managed the family brewery and was cricket Captain for Northamptonshire. Their privileged son was neither destined nor inclined to follow in his father's footsteps.

Tom once told me that his first childhood memory was of being put out on a blanket in the sun before he could walk. He remembered his excitement and freedom at being outside. Tom never lost his passion for open air which propelled him into a life of exploration and adventure. His scientific career began and ended with eggs. As a boy, he had a passion for collecting eggs, and this hobby directed him into a career as a biologist, rather than a brewery owner as his father expected. A friendly gardener sparked his interest in nests, and Tom undoubtedly learned to keep notes and data for his trophies. This mixture of intense interest and attention to detail stood him in good stead as he completed, at the age of seventy, his last pioneering scientific work on weight lost by eggs during incubation for the *Canadian Field-Naturalist*.

Tom was educated at Harrow, and like his father, attended shooting parties and rode with the famous Pytchley Hunt. There were, however, some interesting dissimilarities. He cleaned the skulls of the mammals and birds shot, drying them in his mother's linen cupboard. Eventually, he escaped from the hunt meets because he disliked the formalities and confining clothes.

While at Harrow, Tom took a cycling trip with a school friend and discovered an unsuspected physical trait. As the pair wound their way through country lanes toward the southern coast of England, he found himself farther and farther ahead. With characteristic independence and detachment from social niceties, he left his friend far behind and continued on, solely interested in how far he could travel in one day. At the end of that journey, he was surprised by his endurance. Although he would never admit it, this ability was more than unusual.

After his death, I discovered a buried manuscript, transcribed from a 1931 diary. It gives an account of his first expedition to Iceland and the Faroe Islands with Harrow school friend, "Twitch" Mitchell. Tom's descriptions of unidentified gulls and seabirds revealed how scrupulous his note-taking was at the young age of twenty. Equally remarkable, for a twenty-year old, was the care he took in logistical planning; from deciding on exact food supplies and arranging trans-

Thomas Henry Manning with Massey Medal presented by the Royal Canadian Geographical Society in 1977 with portrait of former Government-General Vincent Massey in background.

portation, to sorting out necessary visas. This thoroughness remained as long as I knew him. Having travelled with him, I could also recognize in that early diary his trademark dry and ironic humour, hidden in pithy comments about the unfortunate "Twitch", disgruntled bureaucrats and miserable weather.

After Harrow, Tom read Natural Sciences at Jesus College, Cambridge. This academic subject captivat-

ed him and provided a continuum with his childhood interest in natural history. Owing to several circumstances, the most prominent being boredom, he never took his degree. Instead, in the summer of 1932, at the age of twenty-one, he embarked on a serious journey, walking the length of the Atlantic coast of Norway on his own. Joined later by Reynold Bray, his close school friend from Harrow, the pair proceeded eastward into Finland, making a winter trip by reindeer sledge through Lapland. In 1932, near the end of their trip, they trespassed into Russia. Tom told me they were arrested by villagers armed with pitchforks, who suspected them of spying. They subsequently spent three weeks in a Leningrad jail, being fed on increasingly weakened soup, until the British Consul secured their release.

Exploration, travel and adventure were now Tom's calling. From 1933-1935, he made a solitary expedition to Southampton Island, northern Hudson Bay, to study a Snow Goose colony. He mapped the island under the auspices of the Royal Geographical Society and collected birds and mammals for the British Museum (Natural History). His longest journeys were made by dogsled in winter. From the Inuit of Coral Harbor (on the island's southern coast) he learned how to build an igloo, drive a dog team and hunt seal and caribou. When I once asked why he had an aversion to dumplings, he replied that during that first summer he had been given flour and baking powder by the Hudson's Bay Company Manager. Given no instructions and being too proud to ask what he should make, he existed on a tiresome diet of dumplings until rescued by the Inuit who showed him how to make bannock.

Tom had no sooner returned to England in 1935 than he started to organize a larger expedition to Southampton Island, and Foxe Basin. The five members of the British-Canadian Arctic Expedition, consisting of Tom, Graham Rowley, Reynold Bray, Pat Baird, Richard (Dick) Keeling and Peter Bennett (who later replaced Dick); arrived in Churchill in May of 1936. A smaller team consisting of Tom, Graham and Pat sailing in the *Polecat,* a 30-foot open whaleboat, established their main base at Coral Harbor. Each pursued his own investigation in biology, archaeology and geology. The expedition was later marred by the tragic death of Reynold Bray, who drowned after being blown out to sea in a collapsible boat.

By the summer of 1938, Tom was alone in the field, at a camp in the Cape Dorset area of southern Baffin Island. He sent a message by Inuit dog team and radio to Montreal to Miss Ella Wallace Jackson (Jackie), a nurse from Nova Scotia whom he had met on the ship that took him back to England in 1935. He invited her to join him in the north. Jackie accepted, and the day after she arrived they were married, using a ring made from a brass fitting by the ship's engineer. A few days later they headed north in a whaleboat. For the next eighteen months they conducted mapping and zoological studies on the west coast of Baffin Island. Jackie later published two books, *Igloo for the Night*, The University of Toronto Press, 1946 and *A Summer on Hudson Bay*, Hodder and Stoughton Ltd., 1949 about their travels together. Although Jackie and Tom spent many years together, the couple separated in the 1960s. Tom often visited her in Ottawa where she still resides.

Tom Manning photograph by Borg Mesch, Kiruna, northern Sweden, 1932.

Late in 1939, Tom had a dream that caused him to head south; he and Jackie arrived in Cape Dorset on 2 January 1940 to learn that World War II had been raging for four months. Anxious to join the war effort, they discovered that the annual resupply ship – due in August – could not get them to Montreal before October. Tom decided they would make their own way back, continuing around the Foxe Basin coast of Baffin Island, hoping to reach Churchill by August. It was 20 January 1941, however, before they reached Churchill, after an epic journey of nearly 2500 miles by boat and dog team, mapping as they went.

Tom received a commission in the Royal Canadian Navy Voluntary Reserve, but was soon seconded to the U.S. Army Engineers to provide advice on the sit-

Tom Manning and Reynold Bray (1911-1936) on expedition 21 October 1932. Photograph T. Dahill of Kiruna, northern Sweden.

ing, construction and operation of an airfield and weather stations on Southampton Island. He spent the rest of the war on defence-related geodetic surveys in the north, as well as the design and development of Arctic clothing and equipment for the armed services. Tom served in the navy from 1941 to 1945, leaving with the rank of Lieutenant Commander.

Following the war, Tom's services were sought by the Defence Research Board, the Geodetic Survey, the Geographical Branch, and other agencies of the Canadian Government. Assignments included the exploration of islands discovered in Foxe Basin by air photographs in 1948, a survey of Banks Island, an oceanographic survey in the Beaufort Sea, and many coastal surveys. Throughout his travels, Tom continued to collect specimens of birds, mammals, plants and occasionally insects. The National Museum of Canada was one of the fortunate recipients of these valuable specimens. In 1949 Tom introduced the seventeen year old Andrew Macpherson to the Arctic. They became fast friends and made several expeditions together, collaborating on many reports of their findings. These journeys, with their combined achievements in the fields of science and exploration, are well known. Accounts of Tom's work have appeared over the last few years in newspapers and journals around the world. In these articles writers have paid extensive tribute to his work. Many of his colleagues and acquaintances noticed that Tom was as much at ease at a formal dinner as on the snow-scoured rock of the Arctic Barrens. However, he preferred the familiar landscape of the Barrens and was able to make himself comfortable in surroundings and circumstances that many civilized people could not endure.

After leaving the North, in 1941, Tom lived briefly in Montreal. Later, he and his wife bought a house in Ottawa on Linden Terrace where they entertained many of their northern friends. Tom started the Arctic Circle Club, 14 November 1947, when the guests no longer fitted around the huge oak dining-table that he had made himself. He was an expert craftsman, making cabinets for his house and building book shelves for his huge library. He and Jackie also spent hours patiently binding many of the collected volumes.

When I first met him in 1965, Tom had given up his Arctic exploration and much of his scientific work. In the tradition of his grandfather T. A. Manning (TAM), he had become a farmer, an occupation which had

always interested him. However, Tom's grandfather in Northampton, had forsaken farming and instead, founded a brewery continued by his son TEM. The prospect of this confining tradition was one of the forces that drove Tom to some of the most remote regions on the planet. However, he made some reconciliation with his heritage about 1960, by purchasing and working over 500 acres of hayfield, pasture and woodlot in the Merrickville countryside, some fifty km south of Ottawa. He, and his Arctic friends, built a cabin on the largest portion of property which he also used for pasture. Tom went on to renovate a stone house and rework the fertile land into a self-sustaining farm with a huge and immaculate vegetable garden, cattle, sheep, chickens and geese.

Tom and I talked a great deal about his northern trips. I finally convinced him that he should go back to his scientific work, and that I would make an excellent assistant! He cut back on the livestock and farming operations, making them manageable for summer and occasional fieldwork. Our first trip was to western Canada collecting birds, mammals and plants. We travelled in a truck, which Tom had skillfully rebuilt as a home on wheels, complete with woodstove. He said it reminded him of caravan holidays as a child, and he always took immense pleasure in its rugged simplicity – often preferring to sleep in it, even when it was parked at home.

My suggestion led to four decades of collaboration. I usually acted as assistant, and collected and prepared the birds with the hunting and skin preparation skills that Tom had taught me. There was ample opportunity for me to paint landscapes and wildlife studies on all the expeditions we made; and Tom was always encouraging and supportive of my work. Occasionally I could provide help with illustrations or maps for his scientific papers. My first trip North with him was to Cape Henrietta-Maria, tagging polar bears for the Canadian Wildlife Service, under the direction of Dr. Charles Jonkel. Although I saw no bears, I fell in love with the land and, from then on, understood and shared Tom's passion for this fabulous country. I was soon to see many bears, and we worked together from 1968 to 1973 on the Circumpolar Polar Bear Project.

During these travels, I had a firsthand chance to see Tom's unique skills. As always, he collected as many types of specimens as he could, and kept extensive field notes and descriptions of everything we encountered. Unlike many Arctic explorers of his time and previously, Tom had a broader range of interests, and documented everything he considered important. At the time, I did not fully comprehend either Tom's skills or his decision-making process. Later, through field experience, I began to understand the brilliance of his mind and abilities.

On one occasion he piloted an open boat in dense fog through seven miles (about 11 km) of the unforgiving waters of James Bay, using dead reckoning and experience to arrive at South Twin Island, exactly on target. On another occasion, attempting an open water crossing on the Belcher Islands, we ran into a dangerous pack-ice jam. This hazard was further compounded by an early snowstorm and a five-foot (1.5 m) tide rip. To stay meant being stranded. To leave meant facing rough water in an overloaded canoe. Tom's choice literally meant life or death. As usual, he made the right decision – elegant in its simple, straightforward truth. Despite the blinding snow he found a path through the heavy waves and got us safely ashore. He always kept part of his mind tuned to the essential core of any situation, a trait which was the quiet binding of his life.

Tom with beached hull of former 1949 expedition ship Nauya behind him, Igloolik, 1983, Photograph by Brenda Carter.

From 1975 to 1986, Tom continued his collecting trips by truck in the summer, spending winters writing papers (a task he disliked) interspersed with his favourite seasonal activities of gardening, cutting fence-posts and filling the woodshed from his hardwood bush. Renewing his interest in his boyhood pursuit of eggs, he began to locate and weigh the eggs of different species. He could often be seen in nearby swamps with his odd, long-legged wooden table, a set of scales and an umbrella to shade the eggs. We both enjoyed the nest hunting and Tom became very interested in the results of his weight loss experiments, but the statistics proved daunting. I often wonder if a modern comput-

er would have helped him with his puzzles. However, his resulting papers were successful, and the most requested from scientists around the world.

In 1983 Tom and I made our last trip north together. As we left Iqaluit for Igloolik, we had a poignant exchange. Looking down at the shorelines and islands that Tom had explored and mapped as a young man, I said that I thought I had come into his life fifteen years too late, and asked him what he felt as he looked down. He said that he thought he also had arrived in the North fifteen years too late! At the age of seventy-five, he continued to dream of an unmapped place and an era when the Arctic was truly beyond the reach of ordinary travel.

On that trip, I noticed that Tom was walking badly; and for the first time since I met him, I realized that I was able to outwalk him. This was startling and worrying and we soon learned that he had Parkinson's disease. However, he continued to work with great energy on the farm. When Parkinson's disease forced him to give up his Arctic work, Tom donated his extensive collection of rare Arctic books along with his field journals and papers to the newly formed library in Iqaluit. He also made a very generous gift of one million dollars to the University of Cambridge towards their new library at the Scott Polar Research Institute. He is remembered there in a special room, the "Manning Archives".

Then, following a broken hip, Tom had to have an operation. This trauma caused the Parkinson's disease to accelerate. After 10 years of his usual bravery and independence, Tom became extremely ill. However, he exhibited the same stoic patience that he had while waiting out a blizzard. One of his last projects was to slowly dig two new flower beds. His dry humour never vanished, but the struggle became very difficult. In November of 1998, at the age of 86 he died. He was in hospital in Smiths Falls near his home, and remarkably at peace. He left many legacies behind, including a gift of $100 000 to the Ottawa Field Naturalist Club. The council decided that 80% of interest from this bequest would go to assist authors with publication charges for the Canadian Field-Naturalist, primarily for northern papers.

Tom was a renowned Arctic explorer and zoologist whose life was characterized by a love of adventure, self-reliance, and an ever-inquiring mind. In fact as Graham Rowley describes in his wonderful book, *Cold Comfort: My Love Affair with the Arctic*, (McGill–Queen's University Press, 1996) what Tom accomplished will never be equalled. He was also a wonderful companion and brilliant teacher, showing by example how to use intuition and logic to unravel a crisis and how to see both facts and beauty in the natural world. He was quiet to the point of being taciturn, and slow to join in the mindless customs of society. But, his loyalty to his friends and to his family in England was complete. Those who were privileged to know him well miss him in many, many ways.

Other tributes to Tom have appeared in several newspaper articles as well as an obituary in *Arctic* 52 (1): 104-105 [March 1999] by Andrew H. Macpherson. Tributes to his disciple Andrew Hall Macpherson (1932-2002) and Manning's role as his mentor have appeared in The *Daily Telegraph* (London, England) 22 June 2002 and in *Arctic* 55(4): 403-406 (December 2002) by Frank L. Miller.

Awards

1944 – Bruce Medal of the Scottish Geographical Society and the Philosophical Society of Edinburgh.
1948 – Patron's Medal of the Royal Geographical Society
1959 – Guggenheim Fellowship held for Arctic research
1974 – Officer of the Order of Canada
1977 – Massey Medal of the Royal Canadian Geographical Society
1977 – Queen's Jubilee Award
1979 – Honorary LLD from McMaster University
1992 – Doris Huestis Speirs Award in recognition of his pioneering work on birds in the Canadian North

Positions in Scientific and Professional Societies

Fellow: Royal Geographical Society; Royal Canadian Geographical Society (also a term as Director) Arctic Institute of North America (also Executive Director 1955-1956).
Member: American Ornithological Union; Wilson Ornithological Club; Cooper Ornithological Club; Wildlife Society; American Society of Mammalogists; Society for American Archaeology. Founder: Arctic Circle Club; 1947 (also Secretary 1948-1950)
Research Associate: Canadian Museum of Nature (1970-1990)

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Manning, T. H. 1948-49. Reports to Defence Research Board. 1. South coast of Hudson Bay, 147 pages, plus photographs, maps, charts, etc. II. West side of James Bay, 185 pages, plus photographs, etc. FV. East coast of James Bay, 295 pages, plus photographs, etc.

Professional Experience

1931 (summer) – Traveled in Iceland and Faro Islands.
1932-33 (winter) – Traveled through Norway, Sweden, Finland, and Russia (Bergen to Murmansk) on foot and with reindeer.
1933-35 – Mapped Southampton Island and also studied and made collections of birds and mammals.
1936-41 – Leader, surveyor and ornithologist on the British Canadian – Arctic Expedition, working in Southampton and Baffin islands and Repulse Bay areas: included two years in Foxe Basin which was circumnavigated by whale boat.
1941-45 – Royal Canadian Navy. Seconded as an advisor to the U.S. Army in connection with the sighting and construction of the air field and establishment by tractor train of outlying weather stations on Southampton Island; and later to the Geodetic Service (Canada) to fix ground controls for air photographic survey of northern Canada (until 1947).
1944 – Geodetic work in Ungava by aircraft and Peterhead boat.
1945 – Geodetic work in west Hudson Bay by aircraft.
1946 – Geodetic work in Ungava, east Hudson Bay and west Hudson Strait by aircraft and Peterhead boat.
1947 – Geodetic work by canoe along the west James Bay and southern Hudson Bay coasts.
1948 – Consultant to Defence Research Board.
1949 – Leader, Geographical Bureau's expedition in C. G. M. V. Nauja to "new" islands in Foxe Basin: included circumnavigation of Foxe Basin. Soundings and tidal observations taken.
1950 – Canoe journey to collect birds and mammals along east James Bay.
1951 – Leader, Defence Research Board expedition to the Beaufort Sea and Master C.G.M.V *Cancolim* (included "circumnavigation" of Alaska). About 4000 miles of soundings taken.
1952 – Leader, Defence Research Board expedition to Banks Island: included attempted circumnavigation of the Island by canoe.
1953 – Completion of circumnavigation of Banks Island.
1954 – Worked up results of Banks Island Expedition under contract with Defence Research Board, and others.
1960 (June to July) – West Coast of North America with Diana Rowley
1967 – Introduction of caribou from Coats Island to Southampton Island for Canadian Wildlife Service.
1968 (June 14 – August) – Western Canada collecting by truck assisted by Brenda and Charlotte Carter; (September) – Cape Henrietta-Maria with Brenda Carter, Dick Russell and Chuck Jonkel for Canadian Wildlife Service.
1969 – Alaska collecting by truck assisted by Z. E. Ellshoff
1970 (July 21 – August) – South Twin Islands, polar bear trapping with Brenda Carter for Canadian Wildlife Service.
1971 (May 2 – September) – Belcher Islands, Sleeper Islands and Ottawa Islands with Brenda Carter for Canadian Wildlife Service.
1972 (May – June) – UK and Norway measuring bear skulls with Charlotte Carter; (September 10 – October 18) -North Twin Island, polar bear trapping with Brenda Carter for Canadian Wildlife Service.
1973 (March 22 – April 17) – Fort George and Belcher Islands, helicopter polar bear tagging with Brenda Carter for Canadian Wildlife Service; (May 2 – August 1) – North Twin Island, polar bear work with Brenda Carter for Canadian Wildlife Service; (August 13 – September 12) – Foxe Basin helicopter work with Brenda Carter for Canadian Wildlife Service.
1975 (May 15 – July 16) – Collecting at North Point, James Bay.
1977 – Yukon collecting by truck and making a floral and faunal inventory of the Dempster Highway assisted by Jan Rowell and Wendy Earl (who departed Dawson City). Robert Porsild and his wife were visited.
1980 – New Brunswick collecting by truck.
1982 – Manitoulin Island collecting by truck assisted by Doug Perkins
1983 – Igloolic Wildlife description. Advisor to adult Inuit for Igloolic Education Council.
1983 – USA (Mississippi, Louisiana, Nevada, Utah and Texas) collecting by truck assited by S. C. Tuutz.
1986 – Yukon collecting by truck (age 77) assisted by Bridget Ryan.
Most of the specimens collected on these trips were sold either to the National Museums of Canada or Carleton University.

A Tribute to Victor Kent Prest 1913-2003

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Dyke, A. S., D. A. Hodgson, E. L. Bousfield, and R. E. Bedford. 2004. A Tribute to Victor Kent Prest 1913-2003. Canadian Field-Naturalist 118(4): 626-629.

With the death of Dr. Victor Kent Prest on 2003 September 26, Canada lost one of its most distinguished, best-known, and most influential Quaternary geologists. Vic was active as a leader of Canadian Quaternary science for a remarkably long time and he positively influenced the careers of almost everyone else in the field in this country as well as his many friends abroad. His work became basic to discoveries by other scientists in related fields such as plant and animal biogeography, both terrestrial and aquatic[4,5,6]. He came to personify the Quaternary Geology of Canada both domestically and internationally. This identity arose from his unstinting and deep interest in the subject, his long view of the evolution of ideas, his intimate knowledge of the ever-growing knowledge base, and especially the very genuine interest he took in the work of all others. Tentative, junior researchers and graduate students always met with as much respect and encouragement as did his senior colleagues and Vic often took the time to send notes of encouragement and compliment.

Victor K. Prest was born in Edmonton Alberta, 2 April 1913, the only child of John (Jack) Prest and Elizabeth Buckley (Prest). His early education was obtained at the MacKay Avenue School in Edmonton. In 1925 the family moved to Toronto for a brief period, and relocated in London, Ontario, where Vic completed his early schooling at Tecumseh Public School and London South Collegiate High School. In 1930 the Prests moved to Winnipeg where Victor completed his secondary education at Kelvin High School. Unrealized by Vic, his future wife Patricia Horder was also attending Kelvin, in the same grade, but in a different classroom. Her father, a Canadian Pacific Railway official, had been transferred from Montreal to Winnipeg in 1926. Vic received his B. Sc. (Honours) from the University of Manitoba in 1935 and his M. Sc. a year later. Growing stronger during these university days was his friendship with Patricia Horder who was active in music, drama, and art, and in the Canadian Girl Guide Association.

Vic worked as a summer assistant for the Manitoba Mines Branch in 1934 and the Geological survey of Canada in 1935 and 1936. While registered for Ph.D. studies at the University of Toronto, Vic was Party Chief, Ontario Department of Mines, from 1937-1940, mainly mapping bedrock outcrops in Northern Ontario. In 1941 Vic received his Ph.D. degree at "Toronto" where he also served as an assistant in both the Geology Department and the Royal Ontario Museum and later as Lecturer. The newly minted Dr. Prest joined the International Nickel Company as a geologist for a year (1941-1942).

Vic and Pat were married in Toronto in 1942 and moved immediately to Harbour Grace, Newfoundland, where Vic served with the RCNVR from 1942-1945. Their first child, Sherron (Sherry) Gail was born there in 1944. Following the surrender of Nazi Germany in early May, 1945, Lieutenant Prest was a member of the naval party accepting the surrender of submarine U190 in St. John's Harbour.

During the next five years Vic was a permanent staff member of the Ontario Department of Mines, based in Toronto, where his son Wayne Horder Prest was born in 1946. In 1950, he transferred to the Geological Survey of Canada in Ottawa. Vic served as Chief of the Pleistocene Engineering and Groundwater Section, first in a third-floor office of the Victoria Memorial Museum building and, following its completion in 1960, in the newly constructed Geological Survey building on Booth Street. Vic formally retired from government service in 1979, but maintained a consultantship office at the Booth St. building until very recently.

Dr. Victor K. Prest is probably best known because of the Glacial Map of Canada (Prest et al. 1968), a work of such veracity that it has yet to be superceded for the country as a whole. This map followed an earlier version initiated by J. Tuzo Wilson, to which Vic contributed as co-compiler (Wilson et al. 1959). The 1968 Glacial Map was followed by the beautiful blue-shaded "pancake map" depicting the Retreat of Wisconsin and Recent Ice in North America (Prest 1969), and his masterful Quaternary Geology chapter in the Geology of Canada volume (Prest 1970). That trilogy was the masterpiece of a generation, which adorned many an academic hallway and classroom. Its impact places it among the most outstanding contributions of the Geological Survey of Canada (GSC) and fixes it as its premier Quaternary contribution. It was the most

VICTOR KENT PREST

cogent, persuasive, and attractively illustrated synthesis available and it has served as the baseline for almost everything else that has followed.

As a great builder of Quaternary science in Canada, Vic had wide knowledge of geological and other sciences. He resumed mapping the Precambrian geology of northern Ontario for ODM (1945-1950) where he authored more than 30 maps and annual reports. He was one of the first to combine Quaternary and bedrock mapping with the release of his map of Red Lake-Lansdowne House. His first Quaternary publication was the Pleistocene geology of the Vermillion River system with special reference to placer gold (Prest 1949).

Vic's early Pleistocene colleagues at GSC included Jack Armstrong, Wes Blake, Jr., Bruce Craig, Bob Fulton, John Fyles, Nelson Gadd, Eric Henderson, Owen Hughes, Bert Lee, and Archie Stalker, all of whom were to become major regional authorities, and Jaan Terasmae and Bob Mott, leaders in the development of Quaternary paleoecology in Canada. Addition of his academic and provincial geological survey friends, Bill Matthews (University of British Columbia), Earl Christiansen (Saskatchewan), Alexis Dreimanis (University of Western Ontario), Con Gravenor (University of Windsor), Paul Karrow (Waterloo University), Pierre LaSalle (Quebec), and John Elson (McGill University) largely completes the Prest cohort of Canadian Quaternary geologists.

Although he departed senior management for full-time research in 1964, even those who joined the Sur-

vey later, and many in outside agencies, identified the Quaternary group with Vic Prest more than with anyone else. Vic became a sort of mentor-at-large, with great moral authority and prestige, and engendered pride in the work of others. By building Quaternary science at the Survey and by mentoring and informally supervising graduate students, Vic profoundly contributed to the Canadian Quaternary community.

Vic was an enthusiastic participant in numerous field excursions in southern Canada, the northern USA, Alaska, and internationally. His GSC fieldwork took him on a High Arctic voyage that reached Ellesmere Island (Prest 1958), mapping projects in Ontario (Prest 1963), Quebec (Prest 1966; Prest and Hode-Keyser 1977) and the Maritimes. He had a special passion for the Maritimes, where his map of Prince Edward Island (Prest 1973) remains seminal, and where, with his protégé Douglas Grant, he formulated the concept of an Appalachian Ice Complex (Prest and Grant 1969; Prest et al. 1972; Prest 1977) to encapsulate the style of regional glaciation, as distinct from Laurentide glaciation. This model is still favoured by regional geologists. The Magdalen Islands in the Gulf of St. Lawrence long held his interest, because of the perplexing lack of direct evidence of Late Wisconsin glaciation and its record of older events (Prest et al. 1976). This evidence led him to portray on his ice recession map what Doug Grant termed "Prest's Problematical Pleistocene Prong", a reference to the glaciological improbability of leaving the Magdalen Islands ice free while allowing ice to extend to the edge of the Continental Shelf. The portrayal revealed Vic's preference for field evidence over theory.

Vic formally retired from GSC in 1978, and formed Veekay Consultants (1978-1994) to receive Ontario Geological Survey (OGS) surficial mapping contracts in northwestern Ontario and a Department of Indian Affairs and Northern Development contract to work in the Bebensee Lake area (Prest 1985). He continued fieldwork into his seventies, including long traverses into dense bush around the famous Red Lake gold mining camp. This work yielded a series of detailed maps (e.g., Prest 1980) that formed the basis for recent drift prospecting programs. His major syntheses included Canada's Heritage of Glacial Features (Prest 1983), the Late Wisconsin Glacier Complex paper and map (Prest 1984), a synthesis of glacial lake history in the Lake Ontario basin with Ernie Muller (Muller and Prest 1985), and maps of North American paleogeography (Dyke and Prest 1987). His two final publications dealt with the history of interpretation of the Laurentide Ice Sheet (Prest 1990) and a more specific passion, the long-distance dispersal of the distinctive erratics that he termed "omarsi" from the central part of the ice sheet (Prest et al. 2000).

Vic was an accomplished athlete and maintained a life-long interest in several sports. During the half century of his residence in Ottawa, Vic's love of tennis became super-seded by a passionate devotion to curling. He was a charter member of the City View Curling Club, founded in 1957, and President the following year. Over the years, he won many curling bonspiels both in men's and mixed rink events, and was ever a formidable shot-maker and curling strategist. He was Honorary Governor General's Curling Club President (1972), Canadian Branch (Royal Caledonia Curling Club), Council of Management (1978-1980) and Life Member (1986). With support from the Ottawa Valley Curling Association, Vic introduced Junior Curling in Eastern Ontario in 1975, and co-ordinated play with the Canadian Branch in Quebec. He also introduced "Little Rock" curling in 1983, and organized Junior and Little Rock bonspiels for the OVCA over a period of ten years. After more than 50 continuous years of winter curling, he "pushed" his last rock at age 89.

Vic's professional career accomplishments received due recognition in the form of the Johnston Medal from the Canadian Quaternary Association (the first awarded), the Gold Medal from the Royal Canadian Geographical Society, the Kirk Bryan and the Distinguished Career Awards from the Quaternary Geology and Geomorphology Division of the Geological Society of America (1993), election as a Fellow to join the distinguished scientists of the Royal Society of Canada, and election as Honorary Member of the International Union for Quaternary Research.

Vic and Pat enjoyed more than sixty years of mutual accomplishment. He loved the out-of-doors and experienced great pleasure whenever he had a chance to stand on a good piece of Precambrian bedrock. Vic was also very generous in his support of charitable organizations, and agencies promoting wildlife conservation and the natural sciences. He will be greatly missed by his family, and by his many friends and scientific colleagues.

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Prest, V. K., J. Terasmae, J. V. Matthews, and **S. Lichti-Federovich.** 1976. Late-Quaternary history of Magdalen Islands, Quebec. Maritime Sediments, 12(2): 39-59.

Wilson, J. T., G. Falconer, W. H. Mathews, and **V. K. Prest.** 1959. Glacial Map of Canada. Geological Association of Canada, scale 1:3 801 600.

Examples of research publications in peripheral fields of science for which the work of V. K. Prest was basic:

Bousfield, E. L., and **M. L. H. Thomas** 1975. Postglacial changes in distribution of littoral marine invertebrates in the Canadian Atlantic Region. Proceedings of the Nova Scotia Institute of Science 27, Supplement 3: 37-42, 8 figures.

Dadswell, M. J. 1974. Distribution, ecology, and postglacial dispersal of certain crustaceans and fishes in eastern North America. National Museum of Canada Publications in Zoology 11: 110 pages, 20 maps.

Pielou, E. C. 1991. After the Ice age. University Chicago Press. Chicago. 366 pages.

Acknowledgments

For providing biographical material, photographs, and personal recollections, the authors are especially grateful to Patricia Prest (wife) and Sherry Armstrong (daughter).

Book Reviews

Zoology

Birds of Australia (Seventh edition)

By Ken Simpson and Nicolas Day. 2004. Princeton University Press, 41 William Street, Princeton, New Jersey, USA, 08540-5237. iv + 92 pages, U.S.$39.50.

When Simpson and Day's first edition appeared (as *Birds of Australia*, later changed to *The Princeton Field Guide to the Birds of Australia*) it meant Australia had a bird guide that was equivalent to North America's National Geographic guide (Dunn 2002). It provided complete coverage of Australian birds in color, with accompanying text and range maps. Curiously the printing was, and still is, poorer than that of the National Geographic.

As with the original this book covers all six states (including Tasmania), three territories and 10 island territories. The new edition has a double page map of the continent, but does not show the island territories.

This revised edition has undergone significant changes from the original. Although much of the content is the same it has been reorganized. More important 19 of the plates have been repainted (actually I counted 24 plates with changes). The illustrations now include more plumage variations than before, such as female, juvenile, winter and different races. In addition to over 2000 colour images there are almost 1000 supplementary black-and-white drawings. One noticeable difference is that the illustration of the dead White-throated Needletail has been replaced with a representation of a live, flying one. Some extra space was generated on the main plates by moving the vagrants to a separate section. This is a better method of dealing with these rare birds.

The introductory material has been reorganized to give a more logical flow. Two small sections – on DNA and prehistoric birds – have been replaced by more pertinent material. All the range maps have been updated. The result is the book is slightly smaller than the original, so the book remains portable in the field.

Within the field information I noted only a few points I would question. The authors tend to lump species that more recently have been separated. These include the Royal and Macaroni Penguins, the Lesser and Greater Snow Petrels and the Yellow and Crimson Rosellas. The Paradise Parrot is still included, despite not having been seen since 1927.

This revised edition, with the original, simpler title of *Birds of Australia* and the expansion of information, makes this field guide a more useful book than the original.

Reference

[1]Dunn, Jon L. 2002. National Geographic Field Guide to the Birds of North America: 4th edition Revised and Updated. National Geographic Society, Washington, D.C.

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The Bird Almanac

By David M. Bird. 2004 Key Porter Books Ltd. 70 The Esplanade, Toronto, Ontario, M5E 1R2 Canada. 460 pages, Can $24.95 Paper.

Within this book is a massive amount of bird-related information! This review could actually end right here. However, I will elaborate somewhat.

Information in this book is presented in three ways: line drawings (restricted to the anatomy chapter), tables/lists as well as glossary-style entries. These are all appropriate and lead the reader to finding information rather quickly. There is both *birding* information and *ornithological* information (and a massive amount of overlap which is shared by both). A glossary of over 20 pages contains over 1000 terms – surely the word you're looking for must be there!

There are simply too many categories of information to give more than a smattering of examples here. Both traditional and genetically-based classifications of bird families are given, followed by the massive list of all known bird species. Significant people are listed in several tables, ornithological award recipients, world-class listers, Taverner Cup winners, bird artists and more. Bird watching clubs, ornithological societies, magazines and journals are listed from sources around the planet.

To compare this book with Leahy's *The Birdwatcher's Companion*, a recent tome of similar intent, would be to have *The Bird Almanac* come on top. The former is essentially all in dictionary format, and therefore lacks the comparative ease (or the ease of comparisons) of the thematically-organized, tabular format in *Almanac*. There are more in-depth definitions and descriptions in *Companion* (it is also a much bigger book), and the bibliography is better- organized, but I believe birders will much more *enjoy* flipping through *Almanac*.

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Handbook of Birds of the World: Volume 9 Cotingas to Pipits and Wagtails

Edited by Josep del Hoyo, Andrew Elliott and David Christie. 2004. Lynx Edicions, Barcelona, Spain. 850 pages, illustrated. Cloth $195 US.

This volume of the *Handbook of Birds of the World* covers 819 species, including Cotingas, Manakins, Tyrant-flycatchers (over 50 % of the book), New Zealand Wrens, Scrub-birds, Lyrebirds, Larks, Swallows and Martins and Pipits and Wagtails. With the publication of this volume *Handbook* has now covered 60% of the world's 197 families of birds. Under the current schedule Volume 10 will be published in 2005 and the final volume, 16, is due in 2011.

It has become very difficult to review these books. Most reviewers, including myself, have already praised the content, the artwork, the scholarship, the format and so on. The quality of all aspects has been remarkably consistent. This volume is no different and it is equivalent to the other volumes.

Volume 9 opens with an essay on ornithological nomenclature by Richard Banks. This is a description of the history, the rules of nomenclature and some of the pitfalls. The author has tabulated some of the most frequently used species names (*cinereus* and its variants is the most used). He also notes that after Linnaeus, the originator of the nomenclature system, Philip Lutley Sclater, a British bio-geographer and taxonomist, has officially named the most birds.

This is a timely essay for Volume 9 because it precedes an unusual situation. Research has shown that a proposed sub-division of the Tyrannidae had not been formally recognized. Therefore the editors published a description of the proposed tribe as required by international protocol. While HBOW is a little different than the usual scientific journal, there is no reason why it should not publish this text.

The breadth of coverage starts with the wildly coloured and sometimes oddball Cotingas, not just the dazzling Cock-of-the-Rock but the bellbirds and umbrellabirds too. The manakins are smaller but also brilliant. I remember stopping dead at the sight of a Red-capped Manakin and being so transfixed I almost missed a much rarer flycatcher; the Sulphur-rumped. But in this edition the flashy birds are overshadowed by the "little brown jobs - LBJs." Just under half of the 429 Tyrannids are olive-grey-brown. Most of the larks and pipits are LBJs too. In fact, about 75% of the species in this volume fall into this category. This includes the dozen or so notorious Empidomax flycatchers and the two dozen tropical Elaenias. To separate these birds you need a good view plus either their song or geographical location to stand a chance at identification. Earlier this year, a colleague and I spent 15 minutes studying a close and very still (it was drizzling) Mountain Elaenia before we were satisfied with its identity.

Even when the Tyranid is brightly coloured with a yellow underside and a black-and-white striped head, then you have 14 look-alikes to contend with. Again geography helps but separating Social and Lesser Kiskadee flycatchers can be tricky.

One of the qualities I have learnt to appreciate more and more about HBOW is the perspective I get by having the entire world taxonomy and distribution at my fingertips. For example, when I encountered a new species, one of the eight African longlclaws (in *Macronyx*) I was able to read about their relationship with other pipits. This despite my tendency to regard them as little meadowlarks (of the purely America *Sturnella*), from their appearance and habits. HBOW brings a focus to the biogeography and family ties to these widespread families.

This access to worldwide taxonomy also raises questions. How can the Temminck's (Horned) Lark of northern North Africa be a different species from the Horned Lark of Europe and North America? The variation in plumage of the latter easily overlaps the paleness of the former (especially *Eromophila alpestris bicornis, E.p. brandti* and *E.p. teleschowi*). Indeed, some years ago, I saw a Horned Lark in Manitoba that was remarkably pale and very close to Temmink's Lark. I have never doubted it was nothing more than a pale version of our common Horned Lark. So I wonder why is Temminck's separate from the Horned Lark, which in turn is split into 42 subspecies? I look forward to Volume 10 to see how the authors handle the stonechats, in particular the very distinctive Madagascan Stonechat.

The editors are continuing to maintain their uniform, high standard and have settled in to a one-per-year production. In this volume they have made another useful change. Previously the plates identified the species by a number only. You needed to turn to the text to match the number with a name. The names of all the species depicted on a plate are now given along with the species number in a footnote opposite the plate.

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British Columbia: A Natural History. Revised and Updated

Richard Cannings, and Sydney Cannings. 2004. Greystone Books, Douglas and McIntyre, Vancouver, British Columbia, Canada. 341 pages, 209 figures. $39.95.

This paperback reprint is a gem. As the title indicates, it is a revised and updated version of a hardcover book first published in 1996, which won the Bill Duthie Bookseller's Choice Award for the "best work published in British Columbia" that year, "The Lieutenant-Governor's Award for Historical Writing in British Columbia," and the Science in Society Award of the

Canadian Science Writers' Association for the best general work. It is an informative, attractive, extremely well-organized book.

The Cannings brothers (identical twins), their brother, Robert, and their late father, Steve, have each contributed masterful photographs. All four are well-known naturalists who have done much to encourage and further the study of natural history through print, radio, and television in western Canada.

The Cannings' book succeeds at a number of levels. Visually it is a delight, with superb, eye-catching maps and photographs, enhanced by informative captions. On initial browse, one is stimulated by the pithy, informative, boxed vignettes, such as "when is a seagull not a seagull?" and "Western Sandpipers." These vignettes will please even the most jaded of naturalists. Finally, the main text provides a wealth of well-organized and thoughtfully developed information. Topics such as geology, the ice age, forests, mountains, grasslands, and water are clearly and incisively presented, as the Cannings' knowledge and enthusiasm shine through. British Columbia is most fortunate to have such masterful and able presenters; nature lovers everywhere will benefit from this book. Only superlatives apply. I cannot think of a single word of criticism.

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Field Guide to Bird Nests and Eggs of Alaska's Coastal Tundra

By T. D. Bowman, 2004. U.S. Fish and Wildlife Service Anchorage, Alaska. Published by Alaska Sea Grant College Program. 81 pages, U.S. $25.00 Paper

This little publication is an interesting add-on for the field practitioner in Alaska and the arctic. This region includes some of the most productive bird nesting areas in North America, and probably in the world. It shows in detail nest and egg features of 70 bird species (loons, waterfowl and crane, jaegers, gulls and terns, owls, ptarmigan, alcids, shorebirds and passerines). Taverner's Canada Goose and Cackling Canada Goose receive separate chapters. The species included in this guide were selected based on their occurrence in Alaska and by their "relative abundance". Some rare species like Sanderling, Surfbird and Yellow-rumped Warbler are unfortunately not included, which will not really help to bring us any closer to their nest discoveries.

This is a convenient book designed to be used in the field. Bird species in this book are ordered by egg size, which makes an interesting presentation. The book design and the photo arrangements are done nicely, but sometimes I find the egg photos a little overdone and repetitive; sometimes wing photos are hard to differentiate. For each species, the photos show the bird (often male and female), bird on the nest, the actual nest, eggs and (down) feathers; but this format is not always strictly followed. Personally, I find it somewhat a shortcoming that chicks are rarely presented in this guide. Of interest is the concept of a "Sizing Chart", which "provides a quick reference to help reduce the number of prospective species to which an egg could belong". Further, the book offers for geese "Parting Shots…" in order to identify escaping birds. A quick reference guide is provided for "Dark Goose Nests."

Six short introduction text pages provide basic background about the species and the book concept. I admire the challenges and amount of field work involved in compiling the specific nest and egg colour photos (over 450). A great photo collection is presented which includes not only, those done by the author but also contributions from over 70 other contributors. As I tend to be creative while in the field, I miss some free pages to write on during field work.

The competent author has over 15 years of experience working in the arctic, and is inspired by the "…dedication to improving the reliability and accuracy of scientific data…". Therefore, it can be hoped that these photos eventually might occur on the internet /www for a free use by the general and interested public.

Overall, I think this interesting book serves it purpose well as a quick field reference and fills a vacant niche. I am sure it will also prove useful for Arctic regions of Canada as well as Russia.

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Guide to Hawk Watching in North America

By Donald S. Heintzelman. 2004. Globe Pequot Press, Guildford, Connecticut. 425 pages, U.S. $16.95 Paper.

The *Guide to Hawk Watching in North America*, written by ornithologist Donald Heintzelman, is an updated version of his *A Guide to Hawk Watching in North America*, published in 1979. The new edition includes updated information about "hawk" (including vultures, eagles, harriers and falcons) biology, identification and seasonal migration movements, as well as numerous additional sites to watch raptors. The new edition adds a separate section on where to view Bald Eagles.

The book is divided into two main parts. The first concentrates on general information, including species accounts for a wide variety of raptors other than owls, tips on how to identify and study hawks, a description of the migration seasons, an overview of different types of hawk watching, an introduction to field equipment for the activity, and an explanation of the mechanics of

hawk flight. The second part of the book focuses on hawk watching sites, including U.S. hawk migration watch sites, Canadian hawk migration watch sites, Bald Eagle viewing areas, and places to view raptors outside the migration season.

The species accounts provide excellent identification information on new world vultures, ospreys, kites, hawks, eagles, harriers, caracaras and falcons. Each species is described in terms of wingspread, total length, field recognition features, flight style, voice, nest, eggs, maximum recorded longevity, food, habitat, and North American range. It makes for an excellent species summary, even if it lacks references to the bird's conservation status.

I found the chapter on mechanics of hawk flights particularly interesting. Although my general understanding of hawk migration was fairly good when I started reading this book, I had never looked into it in great detail. So I was fascinated to read about the influence of general weather conditions, and the use migrating raptors make of deflective updrafts, lee waves, thermals, thermal streets, squall lines, and leading lines.

I was also interested to read about hawk migration watch sites throughout Canada, including Alberta's Canmore Collegiate High School, Nova Scotia's Brier Island near Digby, Ontario's Holiday Beach Migration observatory near Windsor, and Quebec's Morgan Arboretum at the west end of Montreal – a sampling of Canadian migration watch sites with high ratings. Canadian entries in the Bald Eagle watch sites section include British Columbia's Active Pass in the Gulf Islands, Pacific Rim National Park on Vancouver Island, the Fraser Valley Bald Eagle Festival near Mission, the Squamish Valley, the Greater Vancouver Area, and Prince Rupert.

The section on other raptor viewing areas also offers sites in Canada, including Amherst Island and Wolfe Island in Eastern Ontario, both featuring Rough-Legged Hawks and various owls during the winter season. The other Canadian sites for concentrations of raptors outside the migration season are the Yukon's North Klondike Highway and South Klondike Highway. Both areas offer year-round opportunities to see a wide variety of eagles, hawks, falcons and owls.

The *Guide to Hawk Watching in North America* is an extensive and practical information source for anyone interested in raptor watching on this continent. My only objection about the book is its title, which I feel should be changed to *Guide to Hawk Watching in the United States and Canada*, since it lacks any reference to sites outside those two countries.

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Locust: The Devastating Rise and Mysterious Disappearance of the Insect that Shaped the American Frontier

Jeffrey A. Lockwood. Basic Books, New York. Hardcover. 294 pages, Can. $39.00 Paper.

Locust is much more than an account of a single species of insect. In fact, it is everything the dust cover promises: "A fascinating detective story" that delves into "history, culture, religion, and especially ecology, interwoven by the life story of a common insect. …with vivid prose, epic thoroughness and scientific precision." I would add geography and science to that list. Lockwood writes engagingly. He shares his years of detective work, providing details that only a professional entomologist could. His historical delvings put most historians to shame, and his writing skills exceed those of almost any living science writer.

The book opens in Dodge County, Nebraska, in July 1875, a drought year, with clouds of locusts obscuring the sky, their wings crackling like a horrific blaze. Limbs of willows bent to the ground under the weight of the insects, as adjacent cornstalks were stripped bare. When a sheet of insects six inches thick passed over a perpendicular ledge of rock, they caused a roaring noise similar to a cataract of water. In Utah, locust eggs were counted at 743 million eggs per acre. The voracious insects literally ate the clothing off human limbs, then entered homes to eat objects such as window blinds. When domestic chickens gorged on the locusts, their eggs and flesh became inedible. Farmers and their families lost their gardens and crops, and were on the brink of starvation.

The U.S. Army under General Ord saved many farm family lives by far exceeding normal army routine. Ord issued thousands of infantry coats, shoes and military blankets, as well as large amounts of army rations. Lawmakers apportioned money to distribute wheat seed for planting the following spring. Without Ord, thousands would have died.

North America was blessed with hundreds of species of grasshoppers, but only a single species of locust, the Rocky Mountain locust, *Melanoplus spretus*, named by Benjamin Dann Walsh back in 1866, caused such vast destruction. Ingenious but rather ineffective machines such as suction machines and flame throwers were invented to combat the locust; two men and a team of horses could incinerate ten acres of locust-infested fields in a day. One Minnesota community alone had a thousand coal-tar hopperdozers that could harvest 150 000 locusts per hour.

On the scientific front, three entomologists did their best to help combat the locust. Charles Valentine Riley was the state entomologist for Missouri. Cyrus Thomas and Alphaeus Spring Packard, Jr., held similar posts in Illinois and Massachusetts. Riley was able to show that the locust had the potential to increase its population 100-fold from one generation to the next; he argued that for every bushel of locust eggs destroyed, 100 acres of crop could be saved. He founded the Na-

tional Insect Collection and through his efforts a branch unit in economic ornithology arose. This office became the Bureau of Biological Survey and later metamorphosed into today's U.S. Fish and Wildlife Service.

Locust has important Canadian content. Entomologist Norman Criddle of Manitoba devised a widely-used mixture of copper acetoarsenite, molasses and horse manure to combat later outbreaks of somewhat less harmful grasshoppers. Criddle also collected the world's last two specimens of *Melanoplus spretus* on 19 July 1902. Three Saskatchewan men, Paul Riegert, Bill Chapco, and Bob Randell, also helped solve problems discussed in later chapters.

Why did the Rocky Mountain grasshopper become extinct? Five different theories in turn held sway: the spread of alfalfa; the demise of the Bison; changes in weather; overgrazing of grasslands; widespread prairie fires – but each was discredited, though two were later revisited as contributing factors..

To allow DNA studies and do radiocarbon dating, Lockwood determined to find locust specimens entombed in glacial ice for a century or more. His first try, in 1987, yielded a quarter pound of dried grasshopper parts; when results were submitted to a leading entomological journal, the editor rejected the paper and informed Lockwood that "you have mistaken natural history for science." In 1988, Lockwood and colleagues collected 134 specimens of twenty species of grasshopper, but no locust, on the glacier. In 1989, they obtained 4 mg of grasshopper parts, including mandibles that appeared to match those of extant preserved specimens of *Melanoplus spretus*. Finally, in 1990, at the melting edge of glaciers, they collected 250 locust bodies, including 14 males with well-preserved abdomens and genitalia, allowing unequivocal identification and DNA analysis. These insect bodies had taken about 150 years to travel 300 m as the ice moved from the crevasses where they had been entombed.

Why, indeed, had *Melanoplus spretus* become extinct? For once, the unplanned effects of human activity had an effect for the better. Lockwood explains that the "base locality" of the locust was, between outbreaks, restricted to a few relatively small areas in valleys within the Rocky mountains, where eggs could be deposited in sand and gravel. Following European settlement, floods occurred more often due to overgrazing on the slopes, irrigation periodically flooded the valleys, and the locust eggs lost their vitality. Ploughing and harrowing destroyed the eggs. The new alfalfa crops were inimical to development of the locust nymphs. The enigma has been solved.

Lockwood is a consummate writer. His eminently readable book is a detective story, keeping the reader in suspense to the final chapter. Admittedly this review has given away the ending and thus has spoiled some of that suspense, but the pleasure of this book lies more in its details and insights than it does in the suspense. I strongly recommend this book to everyone with an interest in a good story well told.

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Mammals of the World: A Checklist

By A. Duff and A. Lawson. 2004. Yale University Press, P.O. Box 209040 New Haven, Connecticut 06520-9040 USA. 312 pages, U.S.$45.00.

Perhaps I should have bought this book some time ago, or at least its predecessor; *Mammal Species of the World* (Edited by D. E. Wilson, and D. M. Reeder, 1993, Smithsonian Institution Press), which contains the names of the recognized species of mammals documented at that date. So many times I have struggled to understand which species are present in a specific area. With birds this is fairly easy to resolve. English names are reasonably standard and scientific names are the ultimate guide. With birds I have rarely had to probe recent literature to catch up on the latest splits. With mammals this is much more difficult. It took some time to clarify the species and distribution of fur seals. The confusion of English names for wildebeest left me very perplexed. My latest book on African mammals was particularly mystifying. It is a translation from German to English and uses different English names for the plates and the text. The scientific names are not current. Starting with this book it took a lot of work to create a list of lemurs that showed the currently known species and sub-species. With *Mammals of the World* this exercise is simple.

This current list contains 5069 species. From the Wilson and Reader list of 4629 the authors have subtracted 41 species that were extinct prior to 1800. These include such creatures as Steller's Sea Cow, hunted to extinction by 1768. More recently extinct species are left in, presumably as, in theory, there is a chance of still finding one alive. The Thylacine comes to mind. Duff and Lawson have added 522 "new" species. A large portion of these come from two sources. Juliette Clutton-Brock's work on domestic animals has elevated numerous creatures to species status (the Domestic Pig goes from *Sus scrofa* to *Sus domesticus* for example). The second source of change is the assignment of species status to numerous sub-species (Colin Groves of the Australian National University has been active in this exercise). Finally, 41 species have been demoted in synonymy. Sadly this loses us the Queen of Sheba's Gazelle (now a subspecies of the Arabian Gazelle), a romantic loss at least. The changes in all the above categories are fully explained in the appendices. Also included are the nomenclatural changes in scientific names.

The authors say they have followed Wilson and Coles (*Common Names of Mammals of the World.* 2000. Smithsonian Press) version of the English names with corrections and conversion to "well-established names." Generally they do not list alternative names so an animal like the Cougar, or Mountain Lion, or Catamount only gets listed as Puma. When I used the index, being uncertain of the author's choice, I looked up Lion (*Panthera leo*) knowing that Cougar would be nearby. The most odd name I found was Sewellel, the Chinook Indian name for the Mountain Beaver. This was the first time I had seen this name although Audubon used it on his painting of *Aplodontia rufa.*

Naturally I compared the list of lemurs that I had created to that of Duff and Lawson. I was not surprised to find many that I had as sub-species had been elevated to full species. Otherwise the lists were the same except for Grey-brown Mouse Lemur (*Microcebus griseorufus*). R. M. Rasoloarison, S. M. Goodman, and J. U. Ganzhorn first described this cute, hamster-like lemur in 2000. I have since been fortunate to see this little beast in South-western Madagascar. This omission is surprising as the author's references go up to 2002, but to be fair this is a family undergoing constant change.

I was also surprised that Canada was not mentioned in the range of the Red Wolf (*Canis rufus*). John Theberge's work has shown that Algonquin wolves are closer to Red Wolves than the more common Timber Wolf (*Canis lupus*). This information is far more widely known.

For those of us that like to travel and see mammals in their native habitat this book is a good and useful guide. However, it is only a list and, although it will not resolve all taxonomic questions, it will bring clarity and order to your research and therefore it is a valuable reference book. As it is based on Wilson and Reeder's out-of-date book it is more up-to-date, but I understand a revised edition of Wilson and Reeder will be published soon – should we wait?

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Parental Behavior in Lepidosaurian and Testudinian Reptiles: A Literature Survey

Louis A. Somma, 2003. Krieger Publishing Company, Malabar, Florida. x + 184 pages, U.S.$33.50 Cloth.

This book is exactly what it purports to be. It is a summary and exhaustive bibliography of literature on parental behaviour in lizards, snakes, amphisbaenians, tuatara and turtles. Passing reference is also made to literature on other vertebrates including dinosaurs. This book focuses exclusively on behaviour as opposed to physiological adaptations and so, while parental behaviour in some species of snakes and lizards is well known, many readers will be astonished to find turtles included. Yet Somma cites references that provide some evidence of parental behaviour for seven species of turtles.

Fifteen categories of parental behaviour are discussed including defence, thermo- and hydro-regulation, assistance during hatching and facilitated feeding. For those unfamiliar with research in this fascinating field the range and diversity of parental behaviours in these reptiles will intrigue and astonish you. Unfortunately, description and discussion of these behaviours is limited to the first 11 pages of the book. This is followed by 46 pages of tables summarizing the results and guiding the reader to literature on various topics and taxa. The remainder of the book consists of 100 pages of references and an index to subjects and taxa. Readers should be aware that the index is inconsistent as to whether it includes references to taxa within the tables (for example, it does for *Trachemys stejnegeri malonei* but not for *Eumeces fasciatus*).

The primary purpose of the book seems to be to raise the profile of parental behaviour in non-avian reptiles and encourage further research on this understudied phenomenon. It is unfortunate that having read such an enormous amount of information on this topic, Somma does not provide more insights into its evolution and ecological ramifications but perhaps the field is too young for such a synthesis. Certainly for anyone interested in embarking on research into this topic it is an invaluable and relatively inexpensive reference. For those who are most keen on this topic, Somma has also published an addendum to the book (Somma, 2003).

Reference

Somma, L. A. 2003. Parental Behaviour in Lepidosaurs and Turtles: Source Addendum. Bulletin of the Chicago Herpetological Society 38(4): 65-76.

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Prairie Ghost: Pronghorn and Human Interaction in Early America

By Richard E. McCabe, Bart W. O'Gara, and Henry M. Reeves. 2004. 176 pages, U.S.$29.95 Cloth.

The Pronghorn, *Antilocapra americana*, formerly called "antelope," is the "most American" of the continent's terrestrial wildlife, since it is found nowhere else. It is the world's second fastest land animal, and perhaps the most inquisitive. Protuberant eyes allow it a nearly 360-degree field of vision. Large lungs, heart and trachea permit it to achieve great speed.

This historical look at the Pronghorn is thoroughly researched, with informative tables, extensive references, and well-chosen, sumptuous illustrations. It

delves deeply into anthropology. The Pronghorn represented fleetness, alertness, and pertinacity, and was a catalyst in the social structure and welfare of most plains tribes. It is no wonder that many place names today derive from this one species, but who would have expected 108 such instances in Arizona and 79 in Wyoming? Two detailed appendices list dates of eyewitness accounts between 1540 and 1896, and the names of the Pronghorn in each native language. Historical accounts go back to Sahagun in 1569 and Hernandez in 1651, both in Mexico. Lewis and Clark popularized it during their exploratory journey of 1804-1806, and George Ord gave the Pronghorn its binomial Latin name in 1815.

Before Europeans reached the Americas, aborigines hunted the swift-footed Pronghorn with three instruments: sling, atlatl, and bow-and-arrow. A well-conditioned, determined native could sometimes, in spite of his much slower pace, outlast and eventually tire and kill a Pronghorn. More often, stalking, pursuing, surrounding, luring, calling, impaling, ambushing, netting, driving with v-shaped fences, setting prairie fires, and making pitfalls, were the methods used to kill them for food. Pronghorn hunting required more preparation and more co-operative effort than did hunting of the larger Bison. The Pronghorn was then one of the natives' most important food sources, especially where Bison were scarce near the edge of their range. An antelope skin was thinner and lighter than that of a Bison, and thus more suitable for clothing. A native would obtain about 45000 calories from a 43-pound Pronghorn carcass.

Pronghorn bones were used as toys, rattles, awls, pipes, fishhooks and decorations. Sinew served as strings for bows, and for sewing. A skin stretched tightly over a section of hollowed tree formed a drum. Marrow was rubbed on sunburned or chapped lips and skin. A Pronghorn fawn was used as bait on branches above a pit where an Indian patiently waited to catch a Golden Eagle for its feathers. Images of the Pronghorn were used to decorate native pottery, on the walls of caves at ten known sites, and as effigies.

Hunting became much easier after guns spread north from Mexico and guns and ammunition were obtained in trade, but this soon led to squandering of the once-precious resource by a veritable army of 5000 white hunters. From 1874 through 1877, more than 100 000 Pronghorn hides were shipped from the plains annually. As the Bison almost vanished, the Pronghorn became even more important as a food source, and their numbers dwindled as well, from about forty million to fewer than 15000 in 1910. Bereft of their two largest natural food sources, native peoples were overwhelmed, subjugated, displaced, and pauperized of their culture, identity and social options, losing much of their spirit and vitality.

Although three of the four last sections tell a grim story, dealing with the near demise, in turn, of the Bison, the people, and the Pronghorn, the book ends on a positive note with the birth of the conservation ethic. In 1887, Theodore Roosevelt convened a dinner meeting in Manhattan to launch the Boone and Crockett Club; he and the other founders had a strong affection for the Pronghorn, which eventually benefitted from the conservation ethic and philosophy of this fledgling movement.

This attractive, scholarly, modestly-priced book belongs in major libraries. It would make a perfect gift for anyone interested in history, geography, anthropology, or big game hunting on the plains.

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A Guide to the Birds of St. Helena and Ascension Island

By N. McCulloch. 2004. The Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire, SG19 2DL Great Britain. iv + 92 pages, 11 GBP.

The booklet is intended for the visitor and has three parts. The first is an overview of island history from time immemorial to present. The second is a site guide giving where to find birds on these islands. The last part is the bird accounts.

The bird accounts cover 31 species for St. Helena and 46 for Ascension that a visitor is likely to see in a day trip around each island. Of these 11 are seabirds and 10 are shorebirds on St. Helena and 13 are seabirds and 16 shorebirds on Ascension So only about 30 % of the island species are land birds, with most of them being introduced. There have been 41 other attempts at introduction on St. Helena and 9 on Ascension

The account of the history is fascinating and so typical of remote islands, especially after its "discovery" by humans. This is not good bedtime reading though. The destruction of the islands ecosystem is the usual unpleasant tale of wanton destruction misguided mistake and foolish carelessness. There have been 41 failed attempts to introduce everything from a white-eye to an ostrich to St. Helena and 9 attempts on Ascension. This includes the introduction of House Sparrows in 1986 (to be company for a ship-assisted vagrant who arrived in 1985). Will we never learn? On a happier note there are programs underway to restore habitat for around 40 species of endemic plant and 9 species of creepy crawlies (one – the Golden Sail Spider – is illustrated) as well as birds. There are also programs to reduce cats, goats and the like.

The bird finding section is typical of current field guides, portraying the bird on the left and giving information on the right. It covers 28 species. Half of these are seabirds. The remainder are land birds, almost all introduced. The English names are fairly consistent with other texts, but there are no references to alter-

native names. For example Maderan vs. Band-rumped Petrel or Parasitic Jaeger vs. Arctic Skua. The text here along with the rest of the book is good and clear.

The author has added a table of accidental species for the two islands (31 on St. Helena and 46 on Ascension. This did not quite match my own list, but I think the difference is due to the political boundary that includes Tristan de Cunha and Gough Islands, thus adding several Antarctic species)

The artwork consists of watercolours that are refined sketches of birds during their normal activities. This gives a better idea of their jizz than the more formalized field guide style of the recent books, and is more akin to the style of postwar books. Indeed, my favourite is a perky field sketch of a Java Sparrow that fronts the section of land birds on which you can almost count the small number of brush strokes. The reader can compare this with the more "finished" plate in the accounts section.

I found it ironic that the endemic Madagascar Fody was introduced, not from Madagascar but from Mauritius (where it is an introduced threat to the endemic Mauritius Fody) and became so numerous it was part of the St. Helena cage bird trade. How convoluted we make the world.

So why go to these remote places? First there is the attraction of wild oceanic islands. While they are no longer the lush paradise first seen by the Portuguese they still are dramatic. The rich brown cliffs surrounded by blue sea set off the white, guano-capped islands. Second, however diminished, there are good seabird colonies; always exciting places. And last, for the hard core, they are the only places to see Ascension Island Frigate and Wirebird. While remote, these islands are not inaccessible. There are some tours that include them on a cruise, although these are very expensive. Routine commercial sailings leave from Cardiff, Wales and Cape Town, South Africa a few times a year. They dock in St. Helena and Ascension for a day or two – enough time with this guide to see most of the islands birds

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BOTANY

Flora and Climatic Conditions of the North Pacific: A Collection of Scientific Papers

Edited by A. N. Berkutenko, H. G. Lumsden, and D. Lumsden. 2001. Institute of Biological Problems of the North, North-East Scientific Center, Far East Branch, Russian Academy of Sciences. Magadan. 189 pages, No price available.

The subtitle – *A collection of papers* – better indicates the contents of this book than does its lead title. What we have here is a nicely produced small book consisting of papers on flora and vegetation, for the most part, but also one paper each on fungi and ethnobotany, two on seed biology, and one on the influence of air masses from the Sea of Okhotsk on summer temperatures in Japan. An odd mix, but perhaps the inevitable result of the need to collect sufficient papers, achieve critical mass, and gain publication. To one interested in floristics and taxonomy, several of these papers are informative and useful. Since the book is entirely in English, it opens to a wider audience than usual the results of botanical studies in the Russian Far East. The prime mover for this collection was A. N. Berkutenko who wrote entirely or contributed to six of the collected 15 papers. Since it is difficult to generalize the disparate contributions, I will give a précis of each.

Yakubov et al. provide a brief sketch of the physical setting, a history of botanizing, and an annotated checklist of 235 species for the flora of Avachinsky volcano. The next paper by Mochalova describes the very small flora of very small islands of the Commander archipelago and the effects of bird colonies on the vegetation there. Two papers by Khoreva and by Berkutenko et al. discuss the vegetation and flora of two islands in the Sea of Okhotsk and provide checklists for the Yams Islands and Nedorasumenia Island, the latter with the unexpected occurrence of the Asiatic shrub *Caragana jubata*.

Sinelnikova gives a synopsis of the plant cover and a checklist for 454 species of vascular plants found at the Orotuk field station in the upper Kolyma River region. The station lies in larch taiga near the Kolyma floodplain. The *Chosenia arbutifolia* and *Populus suaveolens* of the gallery forest and the *Pinus pumila* communities farther upslope are among the memorable botanical images I took away from my trip to the region. A short paper by Berkutenko and Khoreva, in a structure now familiar, provides a sketch of the vegetation and a checklist to the 98 species found at the Mount Kamenny Venets nature monument, which includes the endemic willow *Salix magadanensis*. Thus ends the first 117 pages. From here on, the papers have less to do with each other or to what has gone before.

A list of 161 macromycetes in the Magadan Preserve by Sazanova is followed by a report by Berkutenko and Yukawa of the first record for the orchid *Liparis kumokiri* for mainland Russian Far East.Next Misako proposes that morphological variation in the Japanese *Sanguisorba tenuifolia* has originated from hybrids between *S. parviflora* and *S. officinalis* occurring in coastal Russian Far East. In a brief, idiosyncratic but interesting essay, Berkutenko contrasts with ethnobotanical anecdotes the changes that have taken place in people's live since Krasheninnikov reported on 18th century habits of the local people on Kamchatka. She includes some differences between practices in the Russian Far East and Alaska as well. This paper is fol-

lowed by comments on the germination of 78 species by Andrianova and Berkutenko: which taxa require pretreatments and which kinds of treatments are efficacious. A paper by Kryukov reports briefly on the relative germination success of 27 species following different periods of storage. Haese describes a phytosociological analysis of coastal tundra using the methods of Braun-Blanquet, and provides tables typical of this analysis. Hanno and Oka in a short paper that reads more like a proposal noted that the Sea of Okhotsk affects the climate of eastern Japan. Pachomov and Sinelnikova present six years of observations on the effect of artificial warming on the growth of four tundra plants at or near the field station described by Sinelnikova (see above). I fear these studies in support of the International Tundra Experiment (ITEX) project will be lost to the ITEX community in these pages; it belongs with others of its ilk.

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ENVIRONMENT

The Russian Far East

By Josh Newell. Second Edition, 2004. Daniel and Daniel, Publishers, McKinleyville, California, USA. 486 pages, U.S.$59.95. Paper.

This is a massive and thorough compendium. The subtitle reads, "A reference guide for conservation and development." The format is a series of chapters each concerning one of the major administrative divisions of the huge region, abbreviated as "RFE." These divisions are: Primorsky Krai, Khabarovsk Krai, Jewish Autonomous Oblast, Amur Oblast, Republic of Sakha, Magadan Oblast, Chukotsky Autonomous Okrug (Chutkotka), Koryak Autonomous Okrug (Koryakia), Kamchatka Oblast, Sakhalin Oblast. There are over 50 maps, and a host of tables, figures and photographs, as well as an index.

Vegetation is organized into the classic Tundra and Taiga formations. This book divides Tundra into two parts: "Arctic Tundra" and "Tundra" (referred to in much Russian ecological literature as "High Arctic" and "Low Arctic.") Taiga is defined correctly as "the large mass of the boreal forest that forms the heart of the RFE." The southern taiga, which in much of Russian ecological literature is known as Ussuri Taiga, is also known as "Dark Taiga" because of the high percentage of spruce and pine.

This division serves to differentiate it from the northern part of the Taiga which is widely known in the Reindeer literature as "Light Taiga" because of the very large percentage of the forest cover of deciduous larch. The Reindeer literature, and much ecological literature, also designates the southern-most tundra, combined with the northern-most taiga as "Forest-Tundra." This recognition of it as a separate entity is undoubtedly because the Forest-Tundra is particularly important as winter pasture for the semi-domesticated Reindeer.

The Ussuri taiga is relatively familiar to English-speaking biologists because of translations of works by such authors as Sdobnikov and Arseniev, as well as Kurosawa's famous 1975 film about Arseniev and Dersu. The number and distinctiveness of the species of plants and animals of the RFE is legendary, especially the Ussuri taiga.

Each of these 10 administrative regions receives a section of the book. Each begins with an overview, ranging from a paragraph or so to a number of pages, followed by extensive entries on: location, size, climate, geography and ecology (including carbon stocks), major ecosystems, protected areas and their problems, biodiversity hotspots, political status, natural resources, main industries, infrastructure, foreign trade, economic importance in the Russian Federation, general outlook.

This latter section is particularly interesting for such items as a full-page table of major environmental issues and problem areas of each of the regions: fishing, energy, timber, mining, agriculture. There are pertinent discussions of the weaknesses of various Russian governmental regulations concerning oil, gas and mining operations compared to the (already-weak) United States and Canadian regulations.

There is discussion of various schemes with potentially-severe effects as well as prospects for a sustainable economy, ENGOs, the UN Global Environment Facility, foreign government aid agencies, other promising sectors such as ecotourism and NTFP (Non Timber Forest Products). There is rather detailed consideration of the degradation of zapovedniks ("protected areas") by tourism, poaching (salmon, caviar), bear killing (for paws and gall bladders).

The forests of Kamchatka are particularly vulnerable and critical for mitigating floods and protection of salmon spawning grounds. (Remember British Columbia?). In the RFE the largest emitter of atmospheric CO_2 is fossil fuels combustion, but second place is deforestation leading to loss of carbon-rich boreal forest and replacement by pioneer types of forests and shrubby vegetation. More than 90 percent of the logging in the RFE is by clearcut. Even plantation-forests do not recover pre-logging stocks of CO_2; managed plantation-forests usually contain only ⅓ to ½ the carbon that undisturbed forests do.

Activities to "Save Tropical Forests" are having adverse effects on the taiga of the RFE... "Plywood manufacturers are promoting Russian larch (tamarack) as a green alternative to tropical luan timber and have been steadily increasing levels over the past decade...

More than 98 percent of all Russian larch grows on some form of permafrost (continuous, discontinuous, sporadic) making large-scale logging of the species an unwise proposition" (page 31).

"The sheer size of the Siberian and RFE forests and the diversity of their plant and animal life and habitats make these forests a tremendously important factor in Russia and the world. Loss of habitat, mostly from forest exploitation, fire, disease and inappropriate management is the most serious threat to the unique biodiversity of climax forests. The survival of endangered species, such as the Siberian Tiger … depends on the maintenance of large, undisturbed forest areas. Fragile permafrost areas must be recognized as environmentally critical and the forests' large contributions to carbon sequestration must not be jeopardized. Such environmental considerations are currently inadequately incorporated in the planning process or not properly addressed in forest management and harvesting activities. As a general requirement for attending to these environmental concerns large forested areas must remain undisturbed and forests outside protected areas need appropriate and complementary management." (page 32)

The Russian Far East has the endangered Siberian Tiger *(Panthera tigris altaica)* while Canada has the endangered Woodland Caribou (*Rangifer tarandus caribou)* (Pruitt and Baskin 2004; Schaefer 2003). Pages 35 – 39 also bring problems in the RFE directly home to Canada: "A major problem is the lack and loss of field scientists and field workers because of dramatic cuts in government funding…" We can compare the situation in the RFE with the massive cuts in scientific staff of Canadian Wildlife Service, National Parks Canada, Canadian Meteorologial Service and the Canadian Museum of Nature, beginning with the Mulroney Conservatives and not restored by later governments. In Canada, the problem is compounded by the growing infatuation of university biology, botany and zoology departments with "computer models" or "keyboard ecology" instead of learning about real animals and plants (Ehrenfeld 1993; Futuyma 1998; Noss 1998).

The book is almost overwhelming in its information: history of European invasions, lists (with comments) of major species of plants and animals, lists of endangered species (usually with comments regarding threats to survival), lists of protected areas by type, size, date of establishment, biodiversity hotspots, human economy and environmental impact.

The sections on Indigenous Peoples and their decline in numbers, relations and their problems with "modern" extractive economy (mining, logging, etc.) is particularly instructive because of the great resemblance to the history of similar Aboriginal groups and their exploitation or rejection by Canadian governments and industries.

We read much in the western press about the widespread pollution and environmental destruction during the Soviet era, but "While the focus has been on nuclear, air, and water pollution and, somewhat less, on the wanton waste of resources caused by inefficient production, scholars have largely ignored what may be the most significant environmental legacy from the Soviet era, and what is Russia's greatest legacy to the planet: wilderness." (page 29).

Although the Russian Far East is well over the shoulder of the world from Canada, the unity of the taiga (so-called "boreal forest") is evident by the similarity of its animals and plants to those in Canada. We can also see in this compendium disturbing similarities to the problems affecting the Canadian taiga (Pruitt and Baskin 2004; Schaefer 2003). Comparison of ameliorating efforts will be valuable. There are many places in Canada which should have copies of this valuable compendium: Federal and Provincial departments of Conservation, Natural Resources, Forestry, Wildlife, Aquatic Resources, Fisheries. All University libraries, the libraries of all ENGOs concerned with conservation and sustainable use of renewable resources, anthropology and aboriginal activists, everyone teaching Field Biology, Ecology, Boreal Ecology, Resource Management, Forestry, Wildlife Management, Fisheries Management or Sustainable Development course or seminar should have access to a copy.

Literature Cited:

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Futuyma, D. 1998. Wherefore and whither the naturalist? American Naturalist 151(1): 1-6.

Noss, R. F. 1998. Does conservation biology need natural history? Wild Earth 8: 10-14.

Pruitt, W. O., Jr., and **L. M. Baskin** 2004. Boreal Forest of Canada and Russia/Taiga of Canada and Russia. Bilingual, English and Russian, parallel texts. Pensoft Publishers, Sofia, Bulgaria, illustrated: 163 pages ISBN 954-642-199-5.

Schaefer, J. 2003. Long-term range recession and the persistence of Caribou in the taiga. Conservation Biology 17(5): 1435-1439.

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Resource and Environmental Management in Canada: Addressing Conflict and Uncertainty

Edited by Bruce Mitchell. 2004. Third Edition. Oxford University Press, Don Mills, Ontario, 608 pages. Can $46.50 Paper.

Canada is a resource-rich country. The nation's history and folklore are a story of resource exploitation and the people who trapped, fished, farmed, mined and lumbered. In many ways, much has not changed as evidenced by the national wealth accrued from natural resources, the dependence of many towns and regions on primary resource use, and the growing social conflicts centred on the type and intensity of resource use and conservation.

It is generally acknowledged that all natural ecosystems are more or less human-dominated. Recent, well-cited studies have estimated that humans appropriate over 30% of the total terrestrial net primary production. This is a remarkable level of consumption for humans that represent roughly 0.5% of the total heterotroph biomass on Earth. Spatially-explicit studies have identified appropriation levels that range from > 6% for South America to > 80% for south-central Asia. North America falls in between with a human appropriation level of 23%.

Given these levels of human domination of the earth's resources, it is understandable that the notions of conflict and uncertainty would be chosen as thematic foci for a book on resource and environmental management; conflict among differing values and ideologies, and uncertainties over adequate scientific and social knowledge.

A long-standing textbook, now in its third edition, *Resource and Environmental Management* is intended primarily for undergraduate university students. The book's 20 chapters are broken down into three parts: (1) emerging concerns, (2) enduring concerns, and (3) contemporary responses to these concerns. Emerging concerns include ecosystem health and ecological integrity, globalization and neo-conservatism, First Nations and resources, feminist perspectives, climate change, and water security. Enduring concerns focus on traditional resource issues such as fisheries, agriculture, forestry, wildlife management, mining, and parks and protected areas. The third part addresses some of the approaches used to develop resource and environmental visions. Among others, these include search conferences, ecosystem approaches, adaptive management, environment impact assessment, participatory approaches, governance issues, and environmental justice. The majority of contributing authors are geography and environmental studies academics.

In any collection of contributed essays, consistency in style and quality is always a challenge. Conflict and uncertainty act as foundational themes and tie together all chapters. Most, if not all authors, attend to this theme and regularly make reference to other chapters in the book. Many of the chapters have been rewritten and updated for this edition and seven new chapters have been added. The editor has prefaced each major section with a good synthesis and summary of each chapter thus helping the reader to situate the individual contributions.

Authors provide a sound scientific and technical analysis of each resource issue, generally up-to-date resource statistics, and policy implications. The strength of the edited volume is the authors' attention to the social, cultural and political dimensions of resource and environmental management. A former forest ecology professor of mine was wont to proclaim: "Forestry is more about people than it is about trees." The same can be said for all other resource issues. Because of the essential human dimension, ecosystem-based natural resource management is not rocket science – it's much more complicated than that. The amalgam of biophysical, cultural and social complexities fuel conflict and promote uncertainty. This inherent complexity of resource and environmental management is highlighted throughout the text. Well discussed, as well, are a number of significant mechanisms that attempt to deal with the often intractable and inherently stochastic dimensions of institutional human behavior.

I found some of the essays unnecessarily long-winded and somewhat pedantic. Twenty chapters weighing in at over 600 pages do not make for easy or necessarily enjoyable reading, especially given the diversity of chapter topics. The chapter on forest management is noticeably remiss in addressing contemporary sustainable forest management paradigms. No mention is given, for example, of the current developments in the emulation of natural forest landscape disturbances, a key concept in sustainable forest management. As an edited book it does not possess the thrill or the fast-paced narrative of a single author. As a textbook, it has all the information, but you may find yourself simply dipping into chapters of specific interest.

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MISCELLANEOUS

Bull's Eye: Unraveling the Medical Mystery of Lyme Disease

By Jonathan A. Edlow. Second Edition, 2004. Yale University Press, New Haven and London. 304 pages. U.S.$29.95 Paper.

There have been few newly-emerging infectious diseases that have generated as much controversy as to their etiology and treatment as Lyme disease. From the "conventional" viewpoint, the disease is easily and accurately diagnosed, and short-term antibiotic treatment is effective; in the "alternative" point of view, the diagnosis of late-presenting cases is often missed due to inaccurate diagnostic tests, and long-term antibiotic treatment of such cases is necessary for a cure. This readable book gives a fair and balanced account of the differing points of view of these two camps. It covers the history of the discovery of Lyme disease, the elucidation of its causative agent, and the development of diagnostic tests and of treatments for the disease.

The disease was first recognized in North America when, around 1975, doctors at the Yale University School of Medicine noticed a new array of symptoms in patients from the area of Lyme, Connecticut. These symptoms consisted of a growing, ring-shaped rash (the bull's-eye) at the site of a tick bite, and swollen joints. Sometimes the rash and the arthritis had appeared without the patient's being aware of a tick bite.

The author, Jonathan Edlow, M.D., is Vice-Chairman of the Department of Emergency Medicine, Beth Israel Deaconess Medical Center, and Assistant Professor of Medicine, Harvard Medical School. He himself describes the book as "a medical detective story" that flowed from a combination of his interest in infectious diseases, and the fact that relatives of his who had moved to the Lyme area in the 1980s were stricken with symptoms of a bizarre arthritis, and/or rashes following tick bites.

The author starts with a detailed and interesting account of how, in the 1970s, residents of the Lyme area were experiencing a baffling array of physical symptoms, including rashes, unexplained neurological symptoms and swollen joints, that eluded diagnosis by their family doctors. Then two women, who together with their families and neighbours, had been ill for several years, were separately urged by their doctors to visit the Rheumatology Clinic at the Yale School of Medicine in New Haven. After hearing their stories, the doctors at the clinic realized that about thirty-five cases clustered in the Lyme area were presenting similar symptoms, and that an investigation into "what was happening at Lyme" was required. At the same time, U.S. Navy doctors at the nearby base in Groton, Connecticut, observed several patients with ring-shaped rashes which spread over a large area. Their case report in *The Journal of the American Medical Association* (JAMA), was read by a family doctor at the eastern end of Long Island who had patients with tick bites surrounded by a rash, who thought that his patients might have the same disease. He realized it was similar to a disease that had been recognized in Europe since 1910 as erythema migrans (EM). In the European reports, the disease was associated with tick bites and thought to have a spirochaete as the causative agent.

Having set the scene, the author describes the isolation of this causative agent by Willy Burgdorfer at the Rocky Mountain Laboratories, U.S. Public Health Service, who demonstrated that a spirochaete found in the deer tick, *Ixodes scapularis*, caused Lyme disease. The organism was later named *Borrelia burgdorferi* in his honour. But this tick can carry other pathogens (e.g., *Babesia* spp.) causing a co-infection in some patients, complicating both diagnosis and treatment. He further describes how, over time, a definite schism arose between the two groups of doctors maintaining the differing viewpoints mentioned. Patient advocacy groups arose who mainly supported the "alternative" position and, in 1993, a U.S. Senate Committee held hearings on the subject. The author sums up the current position by saying that debate remains about the best way to diagnose the disease, the utility of long-term antibiotic treatment, and the safety of a vaccine.

A drawback in the author's style arises when he uses analogies to try to explain scientific concepts. One example is that of a five-page description (complete with 5 Tables!) of the separation of peaches, apples, oranges and nectarines by machine, in an attempt to explain the meaning of the terms *sensitivity* and *specificity* in assessing the accuracy of laboratory tests. The result is confusion.

Appendix A lists the symptoms of Lyme disease, Appendix B lists tick-borne diseases in humans and animals. The book does not have a bibliography but, following the appendices, gives a list of sources for each chapter.

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The Importance of Species: Perspective on Expendability and Triage

Edited by Peter Kareiva and Simon A. Levin. Princeton University Press, 41 William Street, Princeton, New Jersey 08540. 427 pages. U.S.$53.00 Paper.

The ecological impact of the economic system we subscribe to could be viewed as the largest of all possible species removal experiments. Unfortunately for us, this experiment is unreplicatable—we only get one shot at it. From the mid-point things don't look good. When the consequences of our personal actions and public policies are compared to the cataclysmic impact

of an asteroid (we are in the midst of the sixth and greatest wave of extinctions on the planet after all) you know we're in trouble. Still, the overwhelming number of species facing imminent elimination has lead some to ask if we need to protect *every* one? Surely of the millions of species we "share" Earth with there must be a few that we could afford to lose? Especially considering the expense and inconvenience of conservation programs.

"The importance of species" sets out to answer that question. Or at least to summarize the collective experiences of the ecological community in examining the idea of species expendability. The initial impetus for this volume came from a symposium to honour the accomplishments of Robert Paine. Dr. Paine's pioneering work on the importance of species began nearly 40 years ago. His investigations were based on a simple idea: if you want to understand the role of a particular species in a community, remove it and see what happens. He works primarily in rocky inter-tidal zones. It was there he discovered that some species are absolutely critical to that ecosystem: remove one of these "keystones" and the community collapses. This conclusion has since been reached by many other ecologists working in different systems, and the book provides a nice introduction to their work. However, while keystone species have been identified in a variety of settings, their redundant counterparts have been harder to locate.

The strength of this book lies in the diversity of voices that converge on a few common conclusions. The most critical outcome of a great deal of research is the recognition that identifying truly redundant species is an extremely difficult and perhaps impossible task. Each paper presents new obstacles. Louda and Rand present a particularly nasty problem in the first chapter. Native thistles of the Great Plains may initially appear to be expendable as a direct result of their being essential! They argue that the native thistles serve to inoculate the community against the invasion of their exotic relatives. The presence of the native thistles supports populations of herbivorous insects which readily switch to feeding on exotic thistle species that have been introduced to the region. In areas where this has been most successful the exotic thistles have been almost completely excluded from the community. Under these conditions the exotic thistles do not appear to pose a serious threat to the community, so the value of the native thistles is not readily apparent.

More generally, the environmental context may determine the relative importance of a species in a community. A keystone predator at one location may have negligible influence at another (Chapter 2). Similarly, the influence of a species may vary greatly over time (Chapter 3). Think of a herbivorous insect that spends nine years in small, widely scattered populations of minor importance, only to erupt in the tenth year to devastate thousands of hectares of forest (and feed millions of birds…). At a broader temporal scale, Stephen Palumbi (Chapter 15) notes that important ecological associations can evolve rapidly. A species that is redundant now may become an important component of its ecosystem in a few decades. The blink of an eye in evolutionary terms, but an eon measured in funding cycles. Taking a different approach Daniel Simberloff (Chapter 11) examines the impacts of the extinctions or near-extinctions of species one could reasonably assume to be important community members (i.e., American Chestnut, American Elm, Bison etc.). He reveals two related challenges: we have very little data to objectively assess the impacts of these losses, and there is no agreement on what constitutes a significant "ecosystem consequence".

As you would expect from a book with 28 authors the treatment is a little uneven. Given the emphasis on detailed natural history knowledge that many authors present as critical to the question, I was not convinced of the value of theoretical models in predicting which species are expendable. Shahid Naeem's (Chapter 6) discussion of ecosystem reliability models starts from the assumption that species are interchangeable, effectively sidestepping the entire issue.

The most troubling essay is perhaps the most important one in evaluating the concept of expendability. Mary Ruckelshaus, Paul McElhany, and Michael Ford collaborate in reviewing their efforts to conserve Pacific salmon species as part of the American National Marine Fisheries Service. Given that five of six of these presumably economically important species are threatened or endangered, you might expect they would approach their task with the objective of maximizing the viability of the various stocks. On the contrary, they outline the process they followed in determining how many more populations they can afford to lose. This is a chilling glimpse of the possible future of conservation biology. The emphasis is not on how best to protect and enhance our biological heritage. Rather, conservation goals are set in a manner that minimizes their impact on economic objectives.

Egbert Leigh's contribution, "Social conflict, biological ignorance, and trying to agree which species are expendable" (chapter 12) provides an insightful review of the entire debate. He identifies a critical need for basic natural history research if we are to have any hope of understanding the relative importance of individual species. More importantly, he reminds us "that social conflict, whether latent or blatant, is the biggest single obstacle to sound conservation. Suppose for a moment that we were Laplacean demons, able to assess the ecological consequences of each and every extinction. Would this circumstance really cause society to close ranks behind conservation? As the world seems organized to destroy any sense of community among human beings, a greater knowledge of biology is not likely to make it easier for society to agree on conservation policy." Leigh reinforces the value of natural

history in dealing with biological issues, while properly identifying the question of species expendability as part of a larger social problem.

This is an important book, and deserves the critical attention of conservation biologists. In an age when we are pressured to apply a business model to all aspects of our society, it is important to examine the consequences in a rigorous way. The essays in this book allow us to do that. The motivation behind identifying redundant species is that it would allow us to maximize the bang per conservation buck. However, cost-benefit analysis is of very limited value when you cannot quantify either costs or benefits.

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NEW TITLES

†Available * Assigned

Zoology

***Common Birds of Ontario**. By D. Sept. 2004. Calypso Publishing, Box 1141, Sechelt, British Columbia V0N 3A0. 93 pages, Can. $12.95.

†**Birding in Venezuela** (revised edition). By M. Goodwin. 2004 Lynx Edicions Barcelona Spain. 332 pages, U.S.$25.60 Paper.

Birds of the Middle East (Reprint of 1996 edition). By R. Porter, S. Christensen and P. Schiermacker-Hansen. 2004. Princeton University Press, 41 William Street, Princeton, New Jersey, USA, 08540-5237. 480 pages, U.S.$35. Paper, U.S.$65 Cloth.

†**Bumblebee Economics** (2nd Edition). By B. Heinreich. 2004. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 245 pages, U.S.$19.95 Paper.

***Damselflies of Alberta – Flying Neon Toothpicks in the Grass.** By John Acorn. 2004. University of Alberta Press, Ring House 2, Edmonton, Alberta T6G 2E1 Can. $29.95.

Experimental Approaches to Conservation Biology. *Edited by* M. S. Gordon and S. M. Bartol 2004. University of California Press, 2120 Berkeley Way, Berkeley, California 94704-1012. 358 pages, U.S.$75.

***Frogs of Australia.** By J. Turner. 2004. Pensoft Publishers. Acad. G. Bonchev Str., Bl. 6, 1113 Sofia, Bulgaria. 276 pages, Eur 34.50 Cloth.

***How the Earthquake Bird got its name and Other Tales of an Unbalanced Nature.** By H. Shugart. 2005. Yale University Press, P.O. Box 209040, New Haven, Connecticut 06520-9040. 227 pages, U.S. $30. Cloth.

Hummingbirds. By L. Aziz. 2004. Firefly Books Ltd., 3680 Victoria Park Avenue, Toronto. 64 pages, Can. $9.95. Paper.

***Mammals of Australia.** By J. Turner. 2004. Pensoft Publishers. Acad. G. Bonchev Str., Bl. 6, 1113 Sofia, Bulgaria. 216 pages, Eur 38.50 Cloth.

***The Peregrine Falcon Survey in Canada.** *Edited by* U. Banasch and G. Holroyd. 2004. Canadian Wildlife Service 4999 – 98 Ave., Edmonton, Alberta T6X 2X3 Canada. No price available.

Seabirds: a natural history. By A. Gaston. 2004. Yale University Press, Box 209040, New Haven, Connecticut 06520. 224 pages, U.S.$45.00.

***Spiders of Australia.** By T. Hawkeswood. 2004. Pensoft Publishers. Acad. G. Bonchev Str., Bl. 6, 1113 Sofia, Bulgaria. 264 pages, Eur 34.95 Cloth.

***Venomous Reptiles of the Western Hemisphere.** By J. Campbell and W. Lamar. 2004. Cornell University Press, 512 East State Street, Ithaca, New York 14850. 1032 pages (2 volumes), U.S.$149.95.

***Whales and Dolphins of the World.** By M. Simmonds. 2004. The MIT Press, Five Cambridge Centre, Cambridge, Massachusetts 02142. 160 pages, U.S.$29.95 Cloth.

Botany

Atlas of Plants of Nunavik Villages. By M. Blondeau and C. Roy. 2004. Editions Multimondes, 930 rue Pouliot, Sainte-Foy, Quebec G1V 3N9. Can. $34.95.

***Boreal Forest of Canada and Russia.** By W. Pruitt and L. Baskin. 2004. Russian Academy of Science, Leniasky pr., 33, Moscow V-71, Russia. 163 pages, Price not known.

†**Flower Chronicles** (reprinted). By E. B. Hollingsworth. 2004 (original 1958). University of Chicago Press, 1427 East 60th Street, Chicago, Illinois 60637. 300 pages, U.S.$16.

***Gathering Moss – A Natural and Cultural History of Mossess.** By R. Kimmerer. 2004. Oregon State University Press, 102 Adams Hall, Corvallis, Oregan 97331. 176 pages, U.S.$17.95 Paper.

Environment

***Experimental Approches to Conservation Biology.** *Edited by* M. Gordon and S. Bariol 2004 University of California Press. 343 pages, not illus. U.S.$?

†**Rendevous with the Wild – The Boreal Forest.** *Edited by* J. Raffan (ed). 2004. BostonMills Press – Firefly Books Ltd., 3680 Victoria Park Avenue, Toronto, Ontario M2H 3K1 188 pages, Can. $39.95

Miscellaneous

The New Amateur Naturalist. By Nick Baker .2004. Harper Collins HarperCollins Publishers Ltd., Bloor Street East, 20th Floor, Toronto, Ontario M4W 1A8. 288 pages, £14.99 – approx. U.S.$38 Cloth.

Wildlife Spectacles. By Russell A. Mittermeier et al. 2004. Conservation International 1919 M Street, NW Suite 600, Washington, DC 20036. 324 pages, £39.50 – approx. U.S.$74.

News and Comment

RENEW. 2004. Recovery of Nationally Endangered Wildlife in Canada. Annual Report (14)

Contents (36 pages): Highlights of 2003-2004 [Of 160 Endangered, 108 Threatened, and 21 Extirpated species on the November 2003 COSEWIC list: 206 species are wholly or partially covered by recovery plans (completed or in development); 117 species are included in ecosystem or multispecies recovery, to the extent that their range overlaps with the geographic area; 53 show stable or increasing population trend. $30.7 million was expended on recovery (salaries + expenses); Employment was equivalent to about 142 salaried and 23 volunteer people working full-time; 258 organizations made financial contributions; 348 organizations participated on recovery teams] – Report from the Co-Chairs – Figures [4] – Species Recovery – Responsible Jurisdictions – Financial Contributors – Funding per Target – Canadian Wildlife Directors Committee [contacts for species at risk]. The report was produced by the Canadian Wildlife Service of Environment Canada in cooperation with the provinces, territories, Fisheries and Oceans Canada, Parks Canada Agency, Wildlife Management Boards and many individuals and non-government groups. Readers are cautioned (inside front cover): "This information is carefully reviewed but the Canadian Wildlife Service disclaims responsibility for the accuracy of the information contributed".

Calendar: Endangered Reptiles of Canada 2004 and 2005

For 2004, 12 (one for each month) striking black-and-white drawings by various artists portray five turtles, 1 lizard and seven snakes whose surviving Canadian populations are designated as Endangered (Blue Racer), Threatened (Black Ratsnake, Eastern Foxsnake, Stinkpot, Eastern Ribbonsnake [Nova Scotia population], Blanding's Turtle [Nova Scotia population], Eastern Massasauga), Special Concern (Wood Turtle, Five-lined Skink, Eastern Ribbonsnake [Ontario populations], Eastern Milksnake, Spotted Turtle), or Under Review (Prairie Rattlesnake, Blanding's Turtle [Quebec, Ontario] populations). For each species there are brief remarks on appearance, occurrence, habitat and risks to its survival. A 13th species, the Pacific Pond Turtle is featured on the cover as designated "extirpated" despite the lack of credible records that native populations ever existed in Canada with the speculative remark "There is no biogeographic basis for the Pacific pond turtle's range not to have extended in Canada, so current efforts to rebuild populations in Washington State may result in the return of the Pacific pond turtle to southwestern British Columbia". The fine artwork was contributed by Joe Crowly (3), Kathryn Peiman (3), Mandi Eldridge (2), Kevin Kerr (2), Sonya Amin, Marisa Bonofiglio, and Sarah Ingwerson.

In the 2005 version the black-and-white art is replaced by colour photography. The cover head of Western Rattlesnake (*Crotalus oreganus*) from British Colombia [sic] is followed by 7 snakes, 6 freshwater turtles, and one lizard each opposite a monthly calendar page covering December 2004 to December 2005. Each has additional cameo shots of the same species and a paragraph that highlights its status and characteristics. Species represented are Eastern Ratsnake (*Elaphe obsoleta*) [= Western Ratsnake *Elaphe spiloides* of one recent study], Eastern Foxsnake (*Elaphe gloydi*) [= *Elaphe vulpina gloydi*], Wood Turtle (*Glyptemys insculpta*), Spiny Softshell *Apalone spinifera*), Stinkpot (*Sternotherous odoratus*), Massasauga (*Sisturus catenatus*), Eastern Hog-nosed Snake (*Heterodon platirhinos*), Five-lined Skink (*Eumeces fasciatus*), Blanding's Turtle (*Emydoidea blandingi*), Spotted Turtle (*Clemmys guttata*), Racers (*Coluber constrictor*: 3 subspecies), Snapping Turtle (*Chelydra serpentina*), Great Basin Gopher Snake (*Pituophis catenifer deserticola*). The back of the calender features 3 species supposedly extirpated from Canada: Timber Rattlesnake (*Crotalus horridus*), Eastern Box Turtle (*Terrapene carpolina carolina*) and Pacific Pond Turtle (*Actinemys marmorata*). Not mentioned is that the latter two were likely introductions to Canada. Two other forms are not illustrated but listed: Pacific Gophersnake (*Pituophis catenifer catenifer*) and Pigmy Short-horned Lizard (*Phrynosoma douglasii*).

These calendars have been produced by "the Brooks lab" at the Department of Zoology, University of Guelph, Guelph, Ontario N1G 2W1 Canada; (519) 824-4120 extension 58360; e-mail brookslab@hotmail.com. The selections for both calendars are based on the latest status designations by the reptile subcommittee (for which Brooks in chair) of the Committee on the Status of Endangered Wildlife (COSEWIC). See website: www.cosewic.ga.ca. All proceeds from sale of calendars goes to support the Kawartha Turtle Trama Centre in Peterborough, Ontario, established in 2002 to treat injured native turtles and release them back in the wild (website: www.kawarthaturtle.org) and reptile conservation research.

Canadian Species at Risk November 2004

The latest version of the booklet *Canadian Species at Risk* prepared after the November 2004 COSEWIC assessment meeting is available on-line in both PDF and HTML formats on the web site http://www.cosewic.qc.ca/eng/sct5/indexe.cfm

Paper format of this publication will now be available only once a year, following the spring assessment meeting.

Froglog: Newsletter of the Declining Amphibian Populations Task Force (65, 66)

Number 65 (Focus on Australia), October 2004. Contents: DAPTF Seed Grants 2005 – The Impact of Habitat Modification on the Striped Marsh Frog *Limnodynastes peronii* (Amy Gye) – Conservation Status of Australian Frogs (Jean-Marc Hero, Care Morrison, Graeme Gilespie, Dale Roberts. Paul Horner, David Newell, Ed Meyer, Keith McDonald, Frank Lemckert, Michhhhael Mahony, Michaelll Tyler, Will Osborne, Harry Hines, Steve Richards, Conrad Hoskin, Naomi Doak and Luke Shooo) – New Funds available from the DAPTF (Tim Halliday) – Alaska Conference Summary (Deborah Rudis – Froglog Shorts.

Number 66, December 2004. Contents: New Funds available from the DAPTF (Tim Halliday & Don Church) – U.S. Cricket Frog Symposium (Michael Lannoo and Ralph Grundel) – Press Release: Sunburt Frogs a Myth: Pond Scum offers Natural Sunscreen (Larry Licht) – Global Amphibian Assessment (Simon Stuart, Janice Chanson, Neil Cox and Bruce Young) – *Atelopus mucubajiensis* still survives in Andes of Venezuela. Prelimnary Report (Cesar L. Barrio-Ammmmoros, Fundacion AndigennA – The *Atelopus* Initiative: Conserving Endangered Tropical Andeannn Amphibians (Ariadne Angulo, Paul Salaman and Jose Vicente Rodriguez – Book Reviews – Froglog Shorts.

Froglog is the bi-monthly newsletter of the Declining Amphibian Populations Task Force of The World Conservation Union (IUCN)/Species Survival Commission (SSC) and is supported by The Open University, The World Congress of Herpetology, and Arizona State University. These issues were edited by John WIlkinson and Jeanne McKay (65) and Jeanne McKay (66), Department of Biological Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, United Kingdom; e-mail: daptf@open.ac.uk. Funding for *Froglog* is underwritten by the Detroit Zoological Institute, P. O. Box 39, Royal Oak, Michigan 48068-0039, USA. Publication is also supported by Peace Frogs www.peacefrogs.com and by RANA and the US National Science Foundation grants DEB-0130273.

The Boreal Dip Net/L'Epuisette Boreale: Newsletter of the Canadian Amphibian and Reptile Conservation Network/Reseau Canadien de Conservation des Amphibiens et des Reptiles 9(1) December 2004

Editor's Note – Thank You from the Meeting Organizer – Overview of the Annual Meeting [Edmonton, Alberta, 24-27 September 2004] – 2004 Silver Salamander Award Winners [Laura Frits, Steve Brechtel] – 2004 Best Student Presentation [Connie Browne] – Meeting Field Trip: Tyrrell Museum and Reptile World – Meeting Field Trip: Garter Snake Dens – List of Presentations titles at 2004 Annual Meeting – Attendees of the 2004 Annual Meeting [55]. – Membership in CARCNET/RECCAR (contact Bruce Pauli, Canadian Wildlife Service, National Wildlife Research Centre, Carleton University, Raven Road, Ottawa, Ontario K1A 0H3. Web site: http://www.carcnet.ca/).

Marine Turtle Newsletter (106)

October 2004. 28 pages: EDITORIAL Conceptual Problems with the ICUN Red Listing Assessment for the Green Turtle: Move Over Raine Island – GUEST EDITORIAL: Sea Turtles, Red Listing, and the Need for Regional Assessments – ARTICLES: The Trade of Marine Turtles in the Toliara region, Souty West Madagasgar – NOTES: Rat Eradication as Part of a Green Turtle (*Chelonia mydas*) Conservation Prograamme in Indonesia – Fibropapillomatosis and Multiple Fibromas in a Green Turtle from the South Coast of Pernambucoo State, Brazil – First Record of a Leatherback Turtle in Syria – MEETING REPORTS – IUCNMTSG UPDATE – ANNOUNCEMENTS – NEWS & LEGAL BRIEFS – RECENT PUBLICATIONS.

The Marine Turtle Newsletter is edited by Brendan J. Godley and Annette C. Broderick, Marine Turtle Research Group, Centre for Ecology and Conservation, University of Exeter in Cornwall, Tremough Campus, Penryn TR10 9EZ United Kingdom; e-mail MTN@seaturtle.org; Fax +44 1392 263700. Subscriptions and donations towards the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael Coyne (online Editor) Marine Turtle Newsletter, 1 Southampton Place, Durham, North Carolina 27705 USA (e-mail: mcoyne@seaturtle.org).

WARS 1983-2002 Special Annual Report Wildlife Accident Reporting and Mitigation

The British Columbia Ministry of Transportation has published as a CD this report on the Wildlife Accident Reporting System (WARS) which describes its work and achievements of the last 20 years as one of the pioneers and leaders in wildlife accident reporting and mitigation.

The WARS system in used in British Columbia to:

1) quantify the magnitude of wildlife-related vehicle collisions by species
2) identify accident-prone locations and accident trends
3) direct accident mitigation efforts (such as wildlife exclusion fencing and wildlife crossing structures) to problem locations
4) evaluate the effectiveness of accident risk profiles for highway corridors
5) develop species-specific accident risk profiles for highway corridors
6) advance mitigation efforts to protect rare and endangered species
7) establish policies and strategies for accident issues and mitigation iniatives

Copies of the CD can be obtained from Leonard Sielecki, R. P. Bio, MCIP, Engineering Branch, Environmental Management, British Columbia Ministry of Transportation, P.O. Box 9850, Station Provincial Government, Victoria British Columbia V8W 9T5 [location address: 4B – 940 Blanshard Street, Victoria] e-mail: leonard.sielecki@gems9.gov.bc.ca; telephone (250) 356-2255.

The Ottawa Field-Naturalists' Club Awards for 2003

IRWIN M. BRODO, CHRISTINE HANRAHAN, BEVERLY MCBRIDE, and SHEILA THOMSON

At the Club's Annual Soirée, held on 24 April 2004, at St. Basil's Church in Ottawa, awards were once again given to members, and one non-member, who distinguished themselves by accomplishments in the field of natural history and conservation, or by extraordinary activity within the Club. As is frequently the case, there isn't a winner for every potential award and, this year, the Anne Hanes Natural History Award was not given. The following citations for those who did receive an award, however, were read to the members and guests assembled for the event.

Daniel Strickland – Honorary Member

The Ottawa Field-Naturalists' Club takes great pleasure in honouring Daniel Strickland, not only for his renowned studies on Gray Jays, but also for the major role that he has played in fostering an appreciation and enjoyment of natural history by the general public.

Dan earned his Bachelor of Science degree from the University of Toronto, followed by his Master of Science from the University of Montreal, choosing as his thesis the life history of the Gray Jay, which he studied in La Verendrye Park in Quebec.

For more than thirty years, Dan has been studying and documenting Gray Jay behaviour in Algonquin Park, including the dynamics of the Gray Jay family unit, its nesting behaviour, winter survival and food gathering strategies. He is recognized world-wide as an authority on Gray Jays, and has co-authored the account on Gray Jays in the prestigious series, *The Birds of North America.*

In 1970, Dan became Chief Naturalist for Algonquin Park, a position he held until his retirement in 2001. Under his leadership, Algonquin Park's nature interpretation program has become renowned continent-wide. Tens of thousands of park visitors each year enjoy the Park's nature walks, public wolf howls, and natural history slide presentations. In addition, seventeen self-guided nature trails, dozens of natural history publications on subjects as diverse as butterflies, mushrooms, mammals and lichens, as well as a world-class interpretive centre, all had their genesis under Dan Strickland's tenure as Chief Naturalist. In Algonquin Park's lively and informative publication, *The Raven*, Dan shared his broad knowledge and his fascination with nature in more than 300 articles. The interpretive programs he developed have contributed immeasurably to the goal of fostering public understanding and appreciation of nature.

Not the least of Dan Strickland's legacies is his impact on a whole generation of young park naturalists, trained under his guidance, who have moved on to new parks or to new fields of endeavour, profoundly influenced by Dan's insight and his enthusiasm for natural history. In recognition of his contributions to our knowledge of the natural history of Gray Jay, as well as his outstanding career in the field of nature interpretation and public education, it is a pleasure to confer Honorary Membership in the Ottawa Field-Naturalists' Club on Dan Strickland.

Colin Bowen – George McGee Service Award 2003

When Colin Bowen first joined the Birds Committee 13 years ago, committee members recognized a man who would do an excellent job at whatever he took on. Since then, he has put in countless hours of solid, thorough work to keep the OFNC's many bird-related materials coherent and accessible.

Colin is extremely well-organized. With his involvement, information management projects get done effectively. In the mid-90s the Birds Committee urgently needed to consolidate and properly archive over thirty years' worth of bird records and publications that were scattered in homes around the region. Colin formed the backbone of a team that worked for almost three years to bring it all together. He continues to maintain the archives so that, now, anyone can easily find what they need.

As secretary of the Bird Records Sub-committee, Colin has a major task on his hands. Sub-committee membership has changed many times since it first reconstituted itself in the mid-90s, but Colin has stayed. He receives all rare bird reports and prepares and redistributes them to committee members for review. He tracks all debates and decisions at meetings and prepares the sub-committee's minutes and reports. On top of all that, he set up and maintains the extensive cross-referenced bird records database and photo collection.

A visit to the OFNC's website will reveal fine examples of Colin's efforts to bring Ottawa bird resources to the Internet and therefore to a broader community. Visitors can see the online tabular seasonal Ottawa bird checklist, the beautifully tabulated Christmas Bird Count results or the often-consulted Ottawa birding site guide, complete with maps.

Colin has volunteered for the Peregrine Falcon Watch and the Ontario Breeding Bird Atlas. He has helped coordinate many Christmas and Fall Bird Counts. When out of town birders contact the club looking for birding information Colin is one of the generous volunteers who offer hours of their time to take them to our fine birding spots.

Colin does so much work for the Birds and Bird Records committees that we wonder how he finds time to do anything else… but he does. He is a devoted and highly-valued volunteer at the Canadian Museum of Nature and, together with his wife, Pat, were the featured volunteers in the museum's recent newsletter. He is a grandfather, an amateur genealogist, a traveller, and is taking up woodworking. He can also fix or build just about anything.

The OFNC thanks Colin for his tremendous contribution, and for retiring from his job with Bell Canada so he would have more time to come and work with us. He has truly never stopped, and we are proud to present him with this year's George McGee Service Award.

Daniel Brunton – Conservation Award for Members, 2003

The recipient of the 2003 Conservation Award for Members, Daniel Brunton, is an individual well known to members of the Ottawa Field-Naturalists' Club through his active role in Club affairs for over 20 years, including a term as President. Indeed, his name is familiar to many residents of the Ottawa region because he is frequently consulted and quoted as an expert naturalist and conservationist by the Ottawa media. Dan has been an ecological consultant since 1979. The award he is receiving today, however, has to do with only one of his many activities on behalf of wildlife and wild spaces in the region, namely, his role in the establishment of the RiverKEEPER project for the Ottawa River. Dan has done almost 200 studies along the river, both as a professional and amateur naturalist, making him eminently qualified to take this initiative.

The problems associated with keeping track of the positive and negative activities that impact the well-being of the Ottawa River demanded a new approach at coordination. With federal, two provincial, and dozens of municipal jurisdictions coming into play, and the high level of pollution affecting this crucial waterway, an initiative with vision was needed. Dan Brunton, together with some like-minded conservationists, particularly George Brown, a Law professor at the University of Ottawa, and John Almstedt, got together to tackle the problem and recommended that the United States-based *RiverKEEPER Alliance* would provide the best framework within which to proceed. In the spring of 2001, a new Canadian chapter of RiverKEEPER was established with Dan as President. Its mission was to oversee the activities and legislation affecting the health of the river, and to report to the public. This would be done by hiring a full time *KEEPER*. Dan worked tirelessly to secure funding for the project and, after much work, succeeded in getting a three-year Trillium grant. In 2002, Laura Van Loon was appointed River KEEPER, launching the active phase of the project, and, in 2003, Dan was able to step down as President and allow others to carry on.

As a result of Dan Brunton's efforts and vision, the public now has a full-time ombudsman to look after the river, advocating compliance with environmental laws, responding to citizen complaints, identifying problems that affect the river, and suggesting remedies. We are all beneficiaries of these efforts and have Dan Brunton to thank for helping to get the project started. The OFNC is therefore very pleased to present him with this year's Conservation Award for Members.

Friends of the Jock River – Conservation Award for Non-Member, 2003

The OFNC Conservation Award, non-member, is given to a group or individual who has made an outstanding contribution in the cause of natural history conservation in the Ottawa Valley, with particular emphasis on activities within the Ottawa District.

The Jock River originates in the Goodwood Marsh approximately 50 kilometers west of Ottawa and empties into the Rideau River after winding through fields, villages, and the provincially significant Richmond Fen. Many species of fish, birds, mammals and other wildlife depend on this waterway for food, breeding sites and shelter. Over the years large areas of riparian vegetation have been destroyed causing severe silting of the river, which in turn has had a serious impact on flora and fauna of the river and its shoreline. The Friends of the Jock River, a non-profit, volunteer environmental organization, was formed to look at ways of protecting, restoring, and enhancing the Jock River and its watershed.

Working with local landowners, government agencies, recreational users and businesses, the Friends have engaged in numerous projects aimed at restoring the health of the river's ecosystem. The number and types of work they have undertaken is truly impressive.

The Friends have been planting native trees and shrubs at various sites along the river and this is helping restore sections of the river's shoreline to a more natural forested state. One example of their work is the Twin Elm restoration project. This project combines restoration planting with fencing of livestock from the riverbank and installation of a nosepump to meet their needs. Another important project undertaken by the group is *The Rideau Valley Conservation Authority (RVCA) Stream Corridor Riparian Vegetation Survey*. With training provided by the Conservation Authority, they collected data according to OMNR stream survey protocols to determine the ecological health of the river and its shoreline habitat. These data will become part of the RVCA database, which, in turn, will be made available to the Friends on CD to help them plan further riparian restoration projects.

The Friends of the Jock River are involved with issues affecting the entire Jock River Watershed, thus they have been monitoring the ecology of the Richmond Conservation Area and advocating environmentally sound sewage treatment in Munster.

The group is working on detailed guidelines for all future projects, including erosion control, buffering run-off, and enhancing biodiversity in the watershed. They produce a quarterly newsletter, hold regular meetings to which the public is invited, and maintain an informative website.

For their dedicated, inspired, hard-working and thoughtful approach to protecting the health of the Jock River and its watershed, the OFNC is very pleased to give the Friends of the Jock River this Conservation Award.

[Brian Finch, the present President; Eric Snyder, the Secretary; and Neil Barrington, the Past President, accepted the award on behalf of the Friends of the Jock River.]

Pearl Peterkin – OFNC Member of the Year, 2003

This award is given to a member judged to have made significant contributions to the Club during the previous year. Looking back over the previous recipients of this award, it is illuminating to see the many and varied services performed for the Club. From rejuvenating committees, leading an exceptional number of walks, editing *Trail & Landscape*, web site design and maintenance, the list is endless. But one thing is clear: joining the ranks of these hard-working, dedicated souls is no small thing.

About ten years ago, it was decided to comb through back issues of *Trail & Landscape* and select those issues containing articles of significant interest and value (for example, special issues on Butterflies, Reptiles and Amphibians, etc.) and retain a stockpile of these issues to sell. Since that original exercise, however, many more articles of interest have been published and Pearl Peterkin decided it was time to go through another selection process. She brought her suggestion to the Education and Publicity Committee who heartily

endorsed it. A suggestion was made to bundle together all issues on a particular topic and sell them as sets. This meant dealing with the entire 35 year run of *Trail & Landscape*, finding all the relevant issues, combining them, creating multiple sets, pricing them, finding adequate storage space at the Fletcher Wildlife Garden centre and, of course, transporting the finished products to the monthly meetings. During the past year, Pearl was often found ensconced in the back room of the Fletcher Centre, surrounded by stacks of *Trail & Landscape*, creating order out of chaos. She has also spent a lot of time there organizing the Education and Publicity Committee's items so that they are more easily and quickly found.

But it wasn't only during 2003 that Pearl was active in Club affairs. Over the 15 years that Pearl has been an OFNC member, she has been involved with several club committees. In the 1990s she volunteered for three years with the Fletcher Wildlife Garden, becoming one of the stalwarts of this energetic group. In 2000 she took over as Chair of the Education and Publicity Committee at a time when the committee was at a low ebb with no leader. During her three years as Chair she successfully rejuvenated the committee, rounding up new members, finding judges for the Science Fair (which members of this Committee have been involved with for some time), finding volunteers to staff displays at various events, and doing all the other myriad jobs that keep a committee running smoothly. Once the committee was up and running smoothly, Pearl decided to step down from that role and concentrate on other aspects of Education and Publicity committee work.

Many people probably recognize Pearl, even if they don't know her name, because she is the friendly face behind the OFNC sales table at the monthly meetings. It requires a serious commitment to attend every meeting, and, when people rely on you to be there, the responsibility is that much greater. Each month Pearl has to gather together the various sale items and, with the help of some other volunteers, transport them to and from the meeting. She also has to keep on top of new items (such as the new Bird Checklist), and make sure the stock of regular items is in good supply. This dedication has paid off, however, because during the last year the sales table has become a focus of much interest and activity.

In her spare time (what spare time, you may ask), Pearl is an enthusiastic and long time member of the Rideau Trail Association. She also volunteers for Bird Studies Canada's Loon Survey.

The OFNC is fortunate to have such enthusiastic and committed volunteers as Pearl Peterkin. For hard work on the *Trail & Landscape* project as well as all her involvement with the Education and Publicity Committee and her dedication to the club, we are pleased to give Pearl Peterkin the Member of the Year award for 2003.

Errata for *The Canadian Field Naturalist* 118(3)

Inside front cover bottom:

Cover. Intertidal zone on rugged rock headland of the Queen Charlotte Islands, British Columbia. Each dominant species creates a distinct zone. The white lichen is mainly *Coccotrema maritimum* and the black one is almost entirely *Verrucaria maura*. Below the *Verrucaria* is a zone bare of both lichens and marine algae, and, still lower, the algae take over. This caption and photo (the latter in colour) have previously appeared as Figure 64, page 77, in *Lichens of North America* by I. M. Brodo, S. D. Sharnoff, and S. Sharnoff. 2001. Yale University Press, New Haven Connecticut. See article by Brodo and Sloan on lichen zonation, pages 405-424.

On page 408, Figure 2, the islands were omitted.

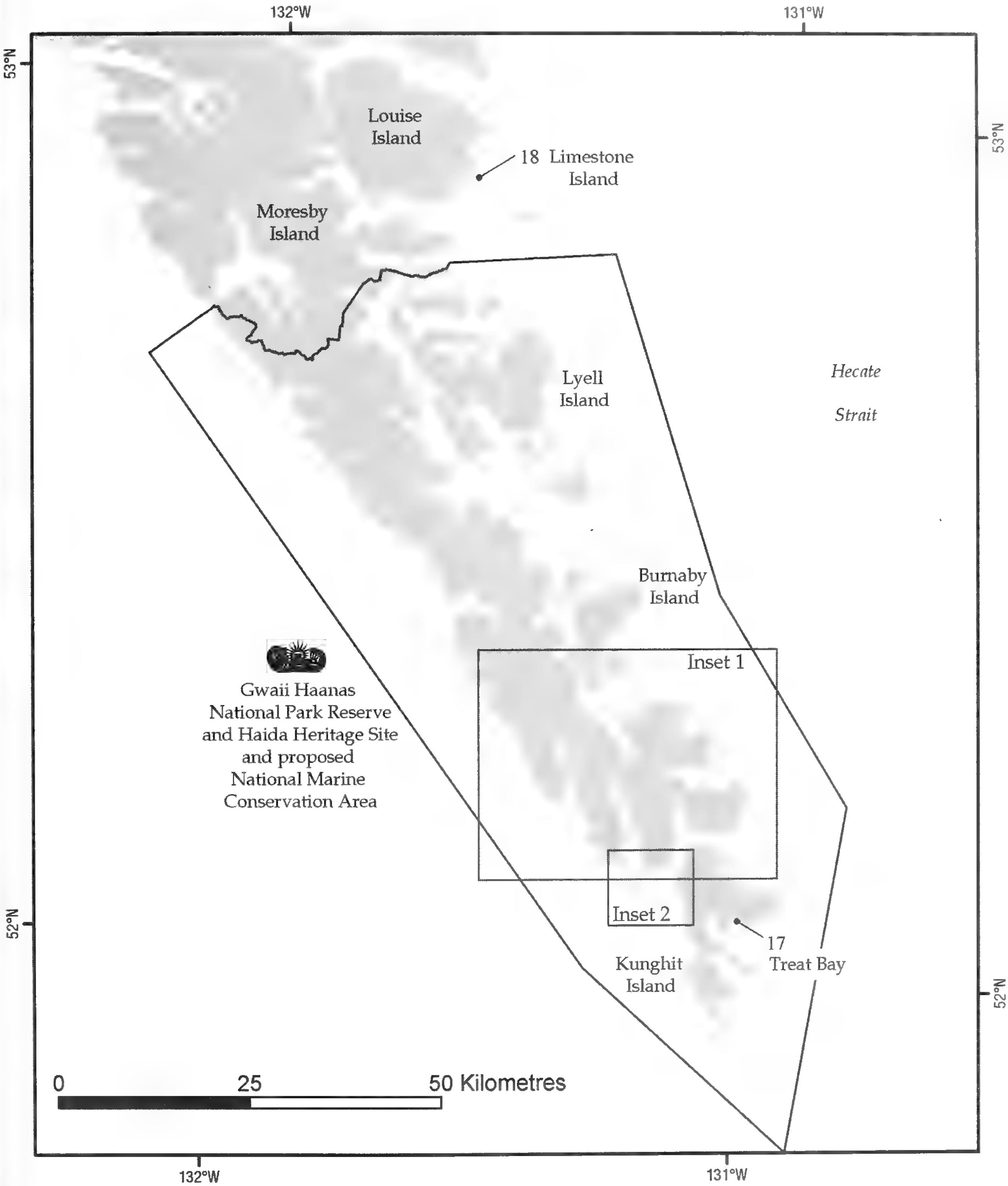

FIGURE 2. Map of the Gwaii Haanas area showing Limestone Island (location 18) to the north and Treat Bay (location 17) to the south of the insets.

Index to Volume 118

Compiled by Leslie Cody

Index to Book Reviews

Botany

Environment

Miscellaneous

Zoology

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Please submit, **to the Editor,** in either English or French, **three** complete manuscripts **written in the journal style.** The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Print the manuscript on standard-size paper, **doublespace throughout,** leave generous margins to allow for copy marking, and **number each page.** For Articles and Notes provide a citation strip, an abstract and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in the text or in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Check recent issues (particularly Literature Cited) for journal format. Either "British" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations

Photographs should have a glossy finish and show sharp contrasts. Electronic versions should be high resolution. Photographic reproduction of line drawings, **no larger than a standard page,** are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the journal.

Special Charges — Please take note

Authors **must share in the cost of publication** by paying \$80 for each page, plus \$15 for each illustration (any size up to a full page), and up to \$80 per page for tables (depending on size). Authors may also be charged for their changes in proofs. Reproduction of color photos is extremely expensive; price quotations may be obtained from the Business Manager. If grant or institutional funds are not available, club members and subscribers may apply for a waiver of charges for the first five pages.

Limited journal funds are available to help offset publication charges to authors with minimal financial resources. Requests for financial assistance should be made to the Editor when the manuscript is accepted.

Reprints

An order form for the purchase of reprints will accompany the galley proofs sent to the authors.

FRANCIS R. COOK, Editor
RR 3 North Augusta, Ontario KOG IR0 Canada

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Articles

Notes

(continued on inside back cover)

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